"A STUDY ON THE BRANCHES AND THE BRANCHING PATTERN OF INTERNAL ILIAC ARTERY" INCLUDING IT'S SURGICAL AND RADIOLOGICAL IMPLICATIONS

Submitted in partial fulfillment for

M.S. DEGREE EXAMINATION

BRANCH - V ANATOMY

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CERTIFICATE

This is to certify that the Dissertation on "A study on the branches and the branching pattern of internal iliac artery including its surgical and radiological implications" , is a bonafide work, carried out in the Upgraded Institute of Anatomy, Madras Medical college, Chennai- 600003, during 2004-2007 by Dr. **S. Sumathilatha** , under my Supervision and Guidance in partial fulfillment of the regulation laid down by The Tamil Nadu Dr. M. G. R. Medical University, M.S. Anatomy Branch –V Degree Examination to be held in March 2007.

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INTRODUCTION

"Variability is the law of life"

-Sir William Osler

The pelvic cavity is the lower extension of the abdominal cavity. The true pelvic cavity usually refers to that part of the pelvis which has as its bony walls, the sacrum and the lower part of innominate bone. This compact area is well packed with highly important structures namely, pelvic viscera, musculature, fascia, vessels, and nerves.

The **internal iliac artery** is found bilaterally in the pelvis. **Hypogastric artery** is the older terminology of internal iliac artery as mentioned in literatures of earlier dates. It is given off by the common iliac artery at its bifurcation anterior to the pelvic brim at the sacroiliac joint level. This forms the important source of vascular supply to all the pelvic viscera, medial side of thigh and gluteal region. The artery descends posteriorly within the pelvic cavity to greater sciatic foramen.

Although variations are frequent, in normal cases, the branches arise from two terminal divisions of internal iliac artery, namely anterior and posterior divisions or trunks. Some of these branches are parietal in distribution while others are visceral branches.

Internal iliac artery in fetus appears to be the continuation of common iliac artery. Instead of dipping into the pelvis, it passes forward to the bladder, and ascends along the sides of that viscus to its summit, to which it gives branches; it then passes upward along the back part of the anterior wall of the abdomen to the umbilicus, converging toward its fellow of the opposite side. Having passed through umbilical opening, the two arteries twine with

umbilical vein and form umbilical cord. The portion of the vessel within the abdomen is called internal iliac artery and that external to that cavity, the umbilical artery. The width of internal iliac artery compared to external iliac artery is diminished in adult, external iliac artery appearing to be in line with common iliac artery.

Among all the branches of internal iliac artery, the larger branches namely, superior vesical artery, inferior gluteal artery, superior gluteal artery and internal pudendal artery show sufficient regularity in their patterns of origin to allow typing. Obturator artery is found to have the most frequent variation among all the branches, in its origin and the course of the artery. Visceral branches are known for their surgical and radiological importance.

The concentration of organs and the anatomical structures within the closely packed confines of the pelvis makes the study of vascular patterns and their variations of much importance. Moreover the role played by embryonic umbilical artery which later on becomes a regressed constituent of internal iliac artery complex in the development of anomalous branches or variations of vascular anatomy is of considerable importance.

AIM OF THE STUDY

The *internal iliac artery* is known to show multiple variations of great importance to surgeons since many years ago. . Even in 18th century, ligation of hypogastric artery was performed for various reasons, the first reported cause being, for the treatment of an aneurysm of gluteal artery in1812 by *Stephens*[1]. From then onwards the procedure has been in vogue for various surgical purposes. Even after bilateral hypogastric ligation, excellent perineal circulation has been observed. This necessitated the detailed study of the branches of internal iliac artery and its collateral circulation with other vessels.

For a longtime, the internal iliac artery was a neglected vessel with few procedures being performed by interventional radiologists, except for a limited number of angioplasties done for significant claudication or erectile dysfunction. Recently, this vessel has become an artery of prime importance to various procedures.[2]

Fibroids are currently treated by **uterine artery embolization** as uterine artery stems from the anterior division of the internal iliac artery. **Pudendal arteriography and iliac angioplasty** are being performed for evaluation and management of *impotency.* Preoperative **internal iliac artery coil embolization** is done for stent graft or operative repair of *abdominal aortic and iliac artery aneurysms* to prevent collateral endoleaks.

Proximal occlusion of internal iliac artery at its origin sufficiently impedes retrograde filling of aneurysm and the development of endoleaks. **Internal iliac artery embolization** is also employed to arrest hemorrhage following parturition, intractable hemorrhage from bladder during surgery for bladder malignancy, rectal or prostatic malignancy and before

hysterectomy for placenta accreta**. Intra arterial chemotherapy** is quite recently used for pain control in patients with *recurrent rectal cancer*[3].

These procedures need expert knowledge about the branches of the internal iliac artery to know the feeding arteries. The incidence of variations in branching pattern of internal iliac artery is quite high which necessitates a thorough acquaintance in detail. These reasons motivated me to develop interest in analyzing the branching pattern of internal iliac artery.

Obturator artery, one of the branches of internal iliac artery has marked variations compared to all other branches. Moreover there are incidences of origin of obturator artery from external iliac artery and its branches, when it is known as "*aberrant obturator artery*". This is at risk of being injured during a corrective surgery for femoral hernia. If both normal and abnormal obturator arteries are present then the vascular arrangement is called as **"circle of death**" because of profuse bleeding that can occur when either vessel is severed[4].

Due to the above said reasons, I have made an effort to study the branches of internal iliac artery with special reference to obturator artery due to its surgical importance. The present study is done with the following parameters.

1. Length of internal iliac artery.
2. Extent of internal iliac artery.
3. Relationship of internal iliac artery to internal iliac vein and ureter.
4. Branches and Branching pattern of internal iliac artery.
5. Obturator artery

REVIEW OF LITERATURE

1. LENGTH OF INTERNAL ILIAC ARTERY:

Gray (1901)[5] quoted that the length of internal iliac artery is about an inch and a half.
In 2/3 rd of the cases it measures1 to 1 ½ inch and in1/3 it is frequently longer than shorter, the maximum length being 3 inches and the minimum is ½ inches.

J.E Frazer (1937)[6] said that the length of internal iliac artery is about 1½ inches. It may be shorter or longer than usual, depending on the length of common iliac artery or according to the height at which internal iliac artery ends into its two divisions.

Grant (1951)[7] stated that the length of internal iliac artery is about 1 1/2 inches

Ronald Bergmann (1988)[8] said that internal iliac artery is seldom less than 2.5 cms in length but may be as short as 1.2 cm or as long as 7.5 cms.

Latha V. Prabhu et al (2001)[9] stated that internal iliac artery is about 4 cms long

2. EXTENT OF INTERNAL ILIAC ARTERY:

Gray (1901)[5] quoted that internal iliac artery arises at the point of bifurcation of common iliac artery, level with the lumbosacral articulation and anterior to sacroiliac joint. Point of bifurcation of common iliac artery is subject to variability. In 2/3 rd or a large number of cases internal iliac artery arises between last lumbar vertebrae and upper border of sacrum. In 1/8th of cases it arises above this point and in 1/6th it is below this level.
The artery passes downward to the upper margin of the great sacrosciatic foramen and divides into anterior and posterior trunks. The place of division varies between the upper

margin of the sacrum and the upper border of sacrosciatic foramen (fig1, 2).

George A Piersol (1930)[10] mentioned that the internal iliac artery arises from common iliac artery and passes almost directly downwards in front of sacroiliac articulation into the pelvis. Opposite to the upper border of greater sciatic foramen it divides into two main stems namely anterior and posterior divisions.

J. Frazer (1937)[6] quoted that internal iliac artery arises from common iliac artery opposite the sacroiliac joint at the level of the lumbosacral joint, and terminates opposite the upper border of the greater sciatic notch by dividing into two divisions.

Morris (1953)[11] described that internal iliac artery arises with the bifurcation of the common iliac artery opposite to the lumbosacral articulation. It descends into pelvis to become continuous with the obliterated portion of the umbilical artery.

Grant (1957)[7] stated that the internal iliac artery arises at the level of lumbosacral articulation, opposite to sacroiliac joint. It ends at the upper border of greater sciatic notch by dividing into two trunks.

Hollinshead (1961)[12] said that internal iliac artery arises opposite the level of lumbosacral articulation and ends at the upper border of greater sciatic foramen. The artery typically ends by dividing into two major trunks, an anterior and a posterior. He also stated that, this division may not be clear cut.

Ronald A. Bergman (1988)[8] stated that the length of internal iliac artery depends on the artery dividing higher or lower than usual. The division may occur anywhere between the pelvic brim and the upper border of the sacrosciatic foramen.

3. RELATION OF INTERNAL ILIAC ARTERY TO VEIN AND URETER:

Gray (1901)[5] stated that internal iliac artery is related in front to ureter which separates it from peritoneum and behind to internal iliac vein, lumbosacral cord.

George A. Piersol (1930)[10] said that internal iliac vein is situated behind and to the inner side of internal iliac artery, and by reason of its size and its close proximity, in ligation of hypogastric artery, the needle should be passed from within outward. The relationship of the ureter, which crosses the vessel obliquely from without inward and downward, should be borne in mind.

Frazer (1937)[6] quoted that internal iliac artery is related anteriorly to peritoneum, ureter. Its posterior relations are internal iliac vein and common iliac vein.

Grant (1951)[7] mentioned that the ureter is related to the anterior border of internal iliac artery. Internal iliac vein, commencement of common iliac vein and sacroiliac joint are posterior and external iliac vein is lateral to internal iliac artery.

Morris (1953)[11] stated that internal iliac artery is related laterally to common iliac vein separating from psoas muscle and obturator nerve, posteriorly to hypogastric vein and in front to peritoneum and ureter.

4. BRANCHES AND BRANCHING PATTERN OF INTERNAL ILIAC ARTERY:

Jastchinski (1891)[13] made the first attempt to group the variations in the origin of the parietal branches of the internal iliac artery into definite patterns. He studied on 640 specimens of Polish subjects which consisted of 400 pelvic halves of newborn and 240 pelvic halves of adults and classified the vessels into three categories.

1. Large caliber vessels (superior gluteal, inferior gluteal, internal pudendal arteries)

2. Medium caliber vessels (obturator artery)

3. Small caliber vessels (iliolumbar, lateral sacral artery)

He found that only large caliber vessels showed sufficient regularity to be grouped into definite types. He described 4 *Types,* which was later modified by Adachi into 5 types.

Parson and Keith (1897)[14] reported on 58 observations of the superior vesical artery that in 44 cases (75.9%) it arose from the hypogastric trunk; in 9 cases (15.5%) it came from the anterior division; in 4 cases (7%) it came from the internal iliac; and in 1 case, in common with the middle rectal, from the hypogastric trunk.

Among these cases, the inferior vesical artery, in 40 of the 58 cases (68.9%) arose as a separate vessel from the hypogastric trunk; in 13 (22.4%) as a separate vessel from the anterior division; in 2 (3.5%) as a separate vessel from the internal iliac. In 3 cases (5.2%) the vessel arose in common with others, twice with the middle rectal, and once with the superior vesical.

Based on their study on 56 specimens regarding the hypogastric trunk, if the internal iliac artery has a low division, a hypogastric trunk may arise, from which the superior vesical, inferior vesical, middle rectal, uterine all originate from this common, hypogastric trunk. In 37(66%) the trunk was a branch of the anterior division; in 13(23.3%) no trunk was present; while in the remaining 6(10.7%) it came from the internal iliac before its division into two. The first type was considered to be typical, based on this report (fig 3 upper left).

Based on 45 observations they found that middle rectal artery, in 15 cases (33.3%) arose from the anterior division; in 10 (22.2%) it came separately from the hypogastric trunk; in 6 (13.3%) it had a common origin with the pudic; in 4 (8.9%) it arose in common with the obturator; in 2 cases (4.4%), in common with the sciatic; in 2 cases, in common with the

inferior vesical; in 2 with the uterine, and in 1 with the superior vesical. In 2 cases it arose by itself from the posterior division, and in one case there were 2 middle hemorrhoidal arteries.

They studied the origin of inferior gluteal artery in 56 specimens and found that in 42 of these (75%) it rose from the anterior division; in 12 (21.4%), from the posterior division; while in one case (1.8%) it arose from the internal iliac. They said that superior gluteal artery must always be the terminal branch of the posterior division.

Levi (1902)[15] described a case of umbilical artery giving rise to vesico-deferential, superior vesical (vesicoanterior) and inferior vesical arteries (vesicoposterior) (fig 4).

Parsons F.G. (1902)[16] stated that the internal pudendal commonly arises from the inferior gluteal outside of the pelvis in mammals; the common stem of the two vessels was usually very long.

Fransen(1907)[17] found that a branching pattern, where inferior gluteal artery and internal pudendal artery are derived from a common stem to be the most common in over twenty species of primates; next in order of frequency were four main vessels arising by 2 common stems , the superior gluteal artery and inferior gluteal artery from one, and the umbilical and internal pudendal artery from the other; the umbilical and internal pudendal originating separately from hypogastric above the common stem for the 2 gluteals; the internal pudendal artery, inferior gluteal artery, and umbilical all arising from a common stem, with the superior gluteal artery arising separately from the hypogastric artery.

Drummond H (1914)[18] stated that he was able to demonstrate a good middle rectal artery in only one fourth of the cases he studied. So he said that the blood supply to rectum from the middle rectal artery is usually not significant.

Lipshutz (1918)[19] conducted a composite study of internal iliac artery and its branches on 181 specimens. He observed 4 forms of branching pattern based on inferior gluteal artery, superior gluteal artery and internal pudendal artery.

In 93 specimens (51%) the superior gluteal artery arises separately from the internal iliac artery, and the inferior gluteal and internal pudendal vessels are given off by a common trunk. In 44cases (24%) the superior and inferior gluteal arteries arise by a common trunk and the internal pudendal vessel separately. In 31 cases (17%) the three branches arise separately from the internal iliac artery. In 13 cases (7%) the three arteries arise by a common trunk.

Poynter (1922)[20] stated that a single lateral sacral artery is found in 55% while 2 are present in 45% of cases. It originates from internal iliac artery in 22% of specimens.

Dubreuil-Chambardel (1925)[21] found a single middle rectal artery in 74% of cases, two arteries in 21%, and three or four arteries in 5% of cases studied. He found that the number of superior vesical artery varies from one to four. A single superior vesical artery was found in 9%; two arteries in 74%; three arteries in 9%; four in 6%; and five arteries were found in 2% of the cases he studied.

He found that vaginal artery may arise from several sources. It arose from the internal iliac artery in 40%; from a common trunk with middle rectal artery in 19%; from a common trunk with the uterine artery.

Adachi (1928)[22] modified the classification of Jastschinski slightly by adding a fifth type of variation and included certain subtypes. He conducted a study of internal iliac artery and its branches namely umbilical artery, superior gluteal artery, inferior gluteal artery and internal

pudendal artery in Japanese subjects. He also reversed the order of types II and III of Jastschinski, since he found a slight preponderance of what had been called type III over type II variety. He conducted an elaborate study on 118 pelvic halves and his findings were as follows (fig 5):

Type I: The superior gluteal artery arises separately from the internal iliac artery, and the inferior gluteal and internal pudendal vessels are given off by a common trunk. If the latter divides within the pelvis it is considered to be Type Ia, whereas if the bifurcation occurs below the pelvic floor it is classified as Type Ib(62 sides; 51.2%)

Type II: The superior and inferior gluteal arteries arise by a common trunk and the internal pudendal vessel separately. If the trunk common to the two gluteal arteries divides within the pelvis it is type IIa and if the division occurs outside the pelvis it is classified as type IIb (28 sides;23.1%).

Type III: The 3 branches arise separately from internal iliac artery (22 sides; 18.2%)

Type IV: The three arteries arise by a common trunk. The sub typing in this group is based on the sites of origin of the superior gluteal and the internal pudendal arteries from the parent stem. In Type IVa the trunk first gives rise to the superior gluteal artery before bifurcating into the other two branches; in Type IVb the internal pudendal is the first vessel to spring from the common trunk, which then divides into superior and inferior gluteal arteries.(5 sides; 4.1%)

Type V: The internal pudendal and the superior gluteal arteries arise from a common trunk, and the inferior gluteal has a separate origin (1 side; 0.8%).

George A. Piersol (1930)[10] stated that from the main stem of the hypogastric artery, before its division, there arises (1) the iliolumbar artery (frequently from posterior division), and

from its posterior division (2) the lateral sacral artery usually two in number and frequently from a common stem, and (3) the superior gluteal artery (as the continuation of posterior trunk).

From the anterior division there are given off (4) superior vesical artery, (5) inferior vesical artery, and (6) prostatic or vaginal branches, and (7) the vesiculodeferential or uterine artery, and in addition, (8) the obturator artery and (9) middle hemorrhoidal arteries, the main stem terminating by dividing into (10) the internal pudendal artery and (11) inferior gluteal artery.

He also said that hypogastric artery represents the proximal part of fetal umbilical artery. The portion of the artery which remains patent forms the main stem of the hypogastric and the superior vesical artery. It passes forward towards the bladder, and gives off branches to it namely *aa.vesicales superiores* which ramify over its surface and sides and supply it's upper and middle portions.

The main stem of the anterior division of hypogastric is really the common trunk by which the inferior gluteal and internal pudendal arise from the hypogastric artery. Internal pudendal artery, occasionally originate with inferior vesical artery or middle rectal artery. Occasionally inferior gluteal artery takes origin from superior gluteal artery or the hypogastric artery.

He quoted that middle hemorrhoidal artery is somewhat variable both in its origin and in its size. It arises from the anterior division of the hypogastric or, from the inferior vesical artery or occasionally from the internal pudendal artery. The inferior vesical artery may arise from the hypogastric, from the middle hemorrhoidal, or quite frequently from the prostatic artery.

In the arrangement of branches of foetal *hypogastric artery* four types are recognized, and corresponding to each of these is an arrangement of the adult hypogastric branches. Leaving out the consideration for the smaller branches there are four types.

The *first type* is that in which two large trunks arise from the hypogastric, the posterior one being the gluteal and the anterior a trunk which divides into the internal pudendal and inferior gluteal. The adult condition which results from this arrangement is that, the main stem of the iliac dividing into two divisions, from the anterior of which the hypogastric arises.

The *second type* is that in which the three vessels arise independently from the hypogastric, the resulting adult condition closely resembling the first type, except that the hypogastric superior seems to arise from the internal pudendal, the separation of the anterior division into its two terminal branches occurring higher up.

The *third type* is that in which the superior gluteal and inferior gluteal arteries arise by a common trunk from the hypogastric, the internal pudendal remaining distinct. In the adult, in such cases, the anterior division gives rise to the hypogastric and the internal pudendal, the inferior gluteal arising from the posterior division.

The *fourth type* is of rare occurrence, where all three large vessels arise from a common stem, in which there will be no apparent separation of the adult hypogastric into an anterior and a posterior division.

J.E. Frazer (1937)[6] classified the branches of internal iliac artery as having two terminal divisions, anterior and posterior of which some are parietal in distribution while others are visceral. The branches are as given in table no. 1

In females inferior vesical artery may be replaced by vaginal artery or vaginal artery may be an independent branch. Uterine artery is always a special branch.

Franklin L. Ashley and Barry J. Anson (1941)[23] dissected 130 specimens (100 white and 30 negro) and described 9 major types – based primarily on the manner of origin of the internal pudendal, the umbilical, and superior and inferior gluteal vessels and forty nine subtypes among these nine major types based on the origin of obturator artery (fig 6) .

Type I. In this rare form the umbilical artery is a continuation of the main trunk, giving off, by a common stem, the other four branches. A single example of this type was encountered (0.4%).

Type II. The four principal arteries arise by a common stem, either with the obturator or with the latter artery as a branch of one of them *(six* examples**,** 2.3%).There are four subtypes in which these arrangements occur.

Type III. The pudendal, inferior gluteal, and umbilical all arise by a common stem, with the superior gluteal arising separately from the hypogastric (twenty-five sides, 9.6%). This main group contains five subtypes.

Type IV. In this type the four main vessels arise by two common stems, the inferior and superior gluteals from one, and the umbilical and pudendal from the other (forty-five sides, 17.3%). There are nine subtypes in this group.

Type V. Here the inferior gluteal and internal pudendal are derived from a common stem; the umbilical and superior gluteal arteries arise above them, by separate stems, from the hypogastric. In some instances the umbilical is first, in others, the superior gluteal; in some cases the two vessels are adjacent. Their variability in position is not a factor sufficient to

warrant a separate grouping, but important enough to justify a placement in a sub-group **(**151 sides, 58.1%). The group contains seventeen subtypes.

Type VI. Here the umbilical and pudendal branches originate separately from the hypogastric above the common stem for the two gluteals; the pudendal appears to be the continuation of the main stem of the hypogastric, with the gluteal as a branch (twenty sides, 7.7%). There are six subtypes in this group.

Type VII. In this group all the vessels arise from the main stem separately, the pudendal appearing to be the continuation of the hypogastric artery (ten sides, 3.8%). There are five subtypes.

Type VIII. In this group 2 gluteal arteries arise by separate stems from hypogastric, but at the same level; the umbilical gives rise to the obturator (single case, 0.4%).

Type IX. The hypogastric divides into a trifid stem; the division being the superior gluteal, the inferior gluteal, and a common stem for umbilical, obturator and pudendal (single side, 0.4%).

In North Americans, the frequency was found to be in the order of V> IV> III> VI> VII> II> I> VIII> IX. Bilateral similarity in branching was observed in 48.46%

They also observed on sixty six sides that the middle haemorrhoidal artery displayed considerable variation, originating from the internal pudendal in 27 of 66 sides studied, from the inferior gluteal in 15, from the obturator, umbilical, hypogastric, vesicals etc., with lesser frequency. This artery may be absent. In all cases, the superior vesicals (usually two to three in number) were derived from the umbilical artery. The inferior and middle vesicals

were derived from pudendal, inferior gluteal, hypogastric, or middle haemorrhoidal arteries (in that order of frequency).

Braithwaite J.L (1952)[24] conducted study on 169 specimens regarding the origin of parietal branches of internal iliac artery and he classified his findings based on Adachi's classification. His observation was as given in table no. 2.

Type I arrangement was the most frequent finding, accounting for 58.5% of all specimens; the common stem for the inferior gluteal artery and internal pudendal artery divided proximal to the pelvic floor in 48.5% of instances, while in 10% the division occurred outside the pelvis. Type III was found in 22.5% and a Type II arrangement in 15.3%; in the latter the trunk common to the two gluteal arteries divided proximal to the pelvic floor in 11.8%, of instances and below this level in 3.5%.The pattern conforming to Type IV was comparatively rare, being present in only 3.6% 0f specimens. Type V arrangement was not found in the series.

In another study[25] on blood supply of bladder, on 27 male adult and 8 infant pelvis he found that in 60% the inferior vesical artery arose from common trunk for internal pudendal artery –inferior gluteal artery or one of these branches commonly from internal pudendal artery (51.4%). In 25.7% of cases, it arose from the internal iliac artery proximal to the origin of this trunk. In 7.1% it was from the umbilical artery, and in 2.9% from superior gluteal artery. He also found that superior vesical artery arises from the pelvic part of the umbilical artery which remains patent. The number varies from one to four as given in table no.3.

Morris: (1953)[11] classified the branches of internal iliac artery into parietal and visceral sets (fig.7). Parietal branches are iliolumbar, lateral sacral, obturator, internal pudendal, superior gluteal, inferior gluteal. Visceral branches are umbilical, inferior vesical, deferential in the

male or uterine in the female and middle rectal artery. Branching pattern is subject to great variation. The so called anterior division and posterior division may not exist at all.
Inferior gluteal artery arises directly from internal iliac artery or from a common trunk with internal pudendal artery or superior gluteal artery. Superior gluteal artery arises from posterior and lateral part of hypogastric artery. Obturator artery may arise separately from hypogastric or in common with one or both of the gluteal arteries. Iliolumbar and lateral sacral (single branch dividing into 2 or as 2 distinct vessels) are most commonly associated with superior gluteal artery.

Of the visceral branches superior vesical artery is almost invariably the last direct branch of hypogastric artery. Others vary greatly as to the sites of origin. Uterine artery is most frequently a direct branch of the hypogastric artery. Inferior vesical and deferential artery arises by a common trunk. Middle hemorrhoidal artery is often associated with the origin of inferior gluteal artery.

Grant (1957)[7] said that all the branches of internal iliac artery may be given off separately from a single undivided parent trunk, but as a rule they arise in two groups that correspond to the two divisions in which the artery appears to end. He stated that the main stem of internal iliac artery may give origin to accessory renal or ureteric branch. The branches are usually classified as parietal and visceral.

The branches from posterior division are all parietal namely iliolumbar artery, lateral sacral and superior gluteal artery. The parietal branches from anterior division are obturator artery, internal pudendal artery, and inferior gluteal artery (takes origin in common with internal pudendal artery or with superior gluteal artery). The visceral branches from anterior division are umbilical, superior vesical artery, middle rectal artery and inferior vesical artery; in addition uterine and vaginal artery in female. Middle rectal artery may not be present.

Robert F. Muller et al (1957)[26] described the need for detailed description of normal roentgenographic anatomy of the arteries of pelvis. The branches of internal iliac artery are variable and unpredictable and its division into anterior and posterior trunks is difficult to identify radiologically. Anatomical variations have not been observed as frequently as reported in anatomical texts. Since most of the variations occur at the sites of origin of the main arteries, roentgenographic identification of the sites of origin is least accurate.

Fischer W (1959)[27] conducted a study on fifty pelvic halves and based upon Adachi's classification, revealed that majority of the cases fall into Type Ia where the common trunk for internal pudendal artery and inferior gluteal artery divides proximal to the pelvic floor in 46% of the cases. No case of type V was observed. His findings are given in table no. 4.

Hollinshead (1961)[12] said that the division of hypogastric artery into two divisions may not be clear cut, and the branches which arise from anterior and posterior trunks may vary considerably, but the posterior trunk tends to be distributed entirely to the body wall and buttocks, while the anterior trunk gives rise to all the visceral branches, including the umbilical artery, and to the obturator, internal pudendal and inferior gluteal arteries. Before it ends in its terminal branches, the hypogastric artery may give off a twig to the pelvic portion of ureter.

Abram (1961)[3] discussed about the applications of pelvic angiography and the related anatomy for the precise localization of traumatic or neoplastic lesions.

Gasparri and Brizzi(1964)[28] adopted a classification based on only 3 types as type IV of Adachi's classification was not distinguished from type III since the two are very similar. The percentage of occurrence of three types is as follows: Type I, 50%; Type II, 31.4%; Type III, 18.6%.

W.H. Roberts & Gene L. Krishinger (1967)[29] based on the dissection of 167 pelvic halves of Caucasian bodies found the branching patterns corresponding with 4 types of Adachi. Type V was not found. One unusual specimen designated as Type VI was described by them in which the inferior gluteal artery was the first major branch.

They studied on the origin of uterine artery on 44 sides and found that it originated from anterior division in 27 specimens (61.4%); from umbilical in 19 sides (43.2%); from internal pudendal artery in a single specimen (2.2%); from a trunk common to inferior vesical artery in a single specimen (2.2%) (Table no.5).

Onnis et al (1967)[30] observed the difficulty in catheterization of internal iliac artery in some cases due to unfavorable angle of bifurcation of the common iliac artery and introduced a new method of selective percutaneous catheterization.

R. J. Last (1972)[31] stated that posterior division gives rise to three parietal branches namely iliolumbar artery, superior gluteal artery and lateral sacral artery. Anterior division gives origin to the parietal branches namely, inferior gluteal artery, internal pudendal artery and obturator artery; visceral branches namely, superior vesical artery, inferior vesical artery and middle rectal artery.

Pac L., Hamplova et al (1977)[32] described an atypical case of origin of a stem - the Truncus Pudendo- Obturatorius from internal iliac artery. This stem divided into obturator artery and arteria pudenda accessoria.

Di Dio LJ et al (1986)[33] studied in 30 cadavers and found that middle rectal artery was present in 56.7% of the cases, bilaterally (36.7%) or unilaterally (20%) originating from the internal pudendal artery (40%), inferior gluteal artery (26.7%), internal iliac artery (16.8%), and less frequently from the other branches.

Ronald A. Bergman (1988)[8] quoted that in some cases the branches arise without the artery dividing into an anterior and posterior division, or one or more branches arise above the division. Branches of the anterior and posterior divisions or the internal iliac may exchange origins.

The internal pudendal artery may arise in common with the obturator or the umbilical. It is always a branch of the anterior division of the internal iliac artery. Inferior gluteal artery may form a common trunk with the superior gluteal.

He also said that middle rectal artery may arise from the internal iliac with the inferior vesical artery. It also arises with or from the internal pudendal, or inferior gluteal arteries. It may be absent. In some cases the artery may be multiple vessels. When there is more than one, they arise from the internal iliac, and/or the inferior vesical, and/or the internal pudendal. Inferior vesical artery may also arise from a common trunk with the internal pudendal and superior gluteal or as a branch from the internal pudendal. It is usually a single branch. (Table no.6)

He said that the number of superior vesical arteries varies from one to five. They commonly arise from the umbilical artery, but were also found arising from the uterine, the vesicodeferential and the obturator artery.

Bilgic S, Sahin B (1997)[35] noted a rare arterial variation that is a common trunk from the external iliac artery for obturator artery, inferior epigastric artery and profunda femoris arteries. This trunk arose from medial side of external iliac artery which divided into ascending and descending branches. Ascending branch divided into obturator artery and inferior epigastric artery. Descending branch was the profunda femoris artery from which originated the medial circumflex femoris artery.

Yamaki .K et al (1998)[34] conducted an elaborate study on 645 pelvic halves of Japanese cadavers. He grouped his findings according to Adachi's classification. He modified the classification into five types and 19 groups. Superior gluteal artery, inferior gluteal artery and internal pudendal artery were defined as major branches and umbilical artery was excluded from this group.

C. N. Puradare (1998)[36] stated that a thorough understanding of the pelvic Vasculature and also of the possible individual variations in the branching pattern of the internal iliac artery is necessary for pelvic surgeons.

Gulsun M et al (2000)[37] demonstrated renal arteries originated from internal iliac artery to supply pelvic kidney. They stated that variations in positional anatomy and vascular supply of pelvic kidney are of clinical importance.

LathaV . Prabhu et al (2001)[9] studied on the variations in the principal branches of internal iliac artery in 20 cadavers (19 male and 1 female) based on Anson and Ashley's classification.

The branches dissected out were superior vesical artery (umbilical artery), internal pudendal artery, inferior gluteal artery, superior gluteal artery all listed as principal off shoots of internal iliac artery. Obturator artery was isolated for observations on its origin. They observed that in Indians the branching pattern is of 3 types. The frequency ratio of the pattern is V > III > IV. No other type was met with. One unusual branching type, was made out. Here internal iliac artery divided into 2 divisions. One stem subdividing into umbilical artery and obturator artery, the other subdivision subdividing into internal pudendal artery, inferior gluteal artery, and superior gluteal artery. Main arterial division into anterior and posterior divisions is brought into question now (table no.7).

Skandalaki (2004)[4] quoted that the bifurcation of internal iliac artery into anterior and posterior divisions is usually very close or distal to its origin at the common iliac artery. Posterior division has three parietal branches namely iliolumbar artery, lateral sacral artery (arises as 1 to 3 vessels) and superior gluteal artery. Anterior division has three parietal branches namely obturator artery, internal pudendal artery and inferior gluteal artery are the two terminal branches and three visceral branches are middle rectal artery, superior vesical artery and inferior vesical artery.

Branching patterns are quite variable. The branches can arise as "spray" of vessels with no distinct formation of anterior and posterior divisions. Visceral branching pattern is of use in localizing uterine artery by the urogynaecologists.

S. Kurup (2004)[38] found a rare branching pattern during routine dissection of a male cadaver. Here, the posterior division gave rise to its usual branches. The anterior division was found to divide into the obliterated umbilical artery, superior vesical artery, inferior vesical artery, internal pudendal artery and the inferior gluteal artery.

Susan Standring (2005)[39] has mentioned that internal iliac artery divides into anterior trunk which continues in the same line towards ischial spine and posterior trunk which passes back to the greater sciatic foramen.

Branches of Internal iliac artery from anterior trunk are superior vesical, inferior vesical, middle rectal, obturator, internal pudendal, and inferior gluteal arteries.

In females: Uterine and Vaginal arteries (vaginal artery replaces inferior vesical artery in females). He said that inferior gluteal artery is the larger of the 2 terminal branches of anterior division and internal pudendal artery the smaller terminal branch.

The branches from posterior trunk are iliolumbar, lateral Sacral (usually 2 in number), and superior gluteal arteries (terminal branch and the largest branch).

The superior vesical artery is the first large branch of anterior trunk. It extends to the side of the bladder, distributing branches to the apex and body of the organ.

He also said that middle rectal artery usually arises together with inferior vesical artery. It supplies the anus and parts outside the rectum, anastomosing with the other hemorrhoidal arteries and inferior vesical artery is distributed to the base of the bladder, the prostate gland, and seminal vesical.

The vaginal artery is analogous to the inferior vesical artery in the male. It descends upon the vagina, supplying its mucous membrane, neck of the bladder and rectum. The uterine artery passes inward from the anterior trunk of the internal iliac artery to the neck of the uterus.

Zdenek Holub et al (2005)[40] modified the anatomical classification of Adachi type I–V for surgical purposes into type I–IV. Laparoscopic retroperitoneal dissection and Laparoscopic dissection of uterine vessels were carried out using an ultrasonic operative technique in all women. The branching of the internal iliac artery was studied on the right side of the pelvis. Of the 100 uterine arteries that were evaluated, 81% were classifiable types and 19% of surgical dissections were inconclusive. Visceral branches arising from the umbilical artery and the internal pudendal artery was claimed to be statistically the most common. They concluded that laparoscopic dissection of the uterine artery close to the origin of the uterine artery can be carried out safely in the most frequent types of surgical classification.

5. OBTURATOR ARTERY

Reid (1836)[41] pointed out, that the normal origin of obturator artery, is from the internal iliac, or one of its branches. The origin next in frequency is by a common trunk with the epigastric from the external iliac. More rarely it springs directly from the external iliac, and still more rarely from the femoral.

Redfern (1850)[42] described a case of common trunk for obturator artery and inferior epigastric artery (fig 8).

Jatschinski (1891)[13] quoted that the abnormal obturator artery is related to the lateral border of the femoral ring in 60% of the cases and across the ligament in 22.5% of cases. It is found along the free edge of the ligament in 17.5% of cases.

Parson & Keith (1897)[14] from their 55 observations they found that in 20 cases (36.4%) obturator artery rose as a separate trunk from the anterior division; in 10 (18.1%) from the deep (inferior) epigastric; ; in 9 (16.4%) separately from the hypogastric trunk; in 8 (14.5%) from the posterior division; in 5 (9.1 %) from the internal iliac before its division; while 3 cases (5.4%) it rose in common with the middle rectal artery.

Gray (1901)[5] stated that obturator artery usually arises from anterior trunk of the internal iliac artery and frequently from posterior trunk. It passes through the obturator foramen and escapes from the pelvic cavity. The pubic branch of obturator artery ascends on the back of os pubes, communicating with offsets from deep epigastric artery and with the corresponding artery of the opposite side. In 2/3rd of cases obturator artery is from internal iliac artery. In 1/3rd of cases obturator artery is from external iliac artery or its branch namely inferior epigastric artery.

The origin of obturator artery from inferior epigastric artery is not commonly found on both sides of the same body. When obturator artery arises at the front of pelvis from epigastric artery, it descends almost vertically to the obturator foramen. Here it lies on the outer side of the femoral ring. Occasionally it curves inwards along the free margin of Gimbernat's ligament and would almost encircle the hernial sac. Here it would be in great danger of being wounded if an operation was performed (fig 9).

Levi (1902)[15] observed a case of origin of obturator artery from 2 branches, obturatoria superiore from internal pudendal and obturatoria inferiore from superior gluteal artery (fig 10).

Poynter (1922)[43] dissected 400 specimens and compared the findings with that of early observations by others as given in table no.8 and found that obturator artery arises from inferior epigastric artery in 25.1%. After an elaborate study he came to a conclusion that, the obturator artery is very variable in origin and no embryological explanation has been found. He suggested that the study of embryos of about the 33 mm stage should settle the question.

Dubreuil Chambardel (1925)[21] dissected 440 specimens and found obturator artery arising from inferior epigastric artery in 29.5% of cases. He described 16 variations in the origin of obturator artery (fig11). He summarized the findings of different authors regarding the sources of the obturator artery and found that obturator artery arises from external iliac artery or its branch in 28.4% of cases (table no.9).He also found that bilateral origin of obturator artery from external iliac artery to be 23.7% from the findings of many authors (Table no. 10).

Adachi (1928)[22] stated that the two roots of obturator artery occur more frequently than indicated because of the difficulty in recognizing the smaller root.

George A. Piersol (1930)[10] quoted that Arteria Obturatoria arises from anterior division of the internal iliac artery. A pubic branch (ramus pubicus) arises just before the artery enters the obturator canal and ascends upon the posterior surface of os pubis to anastamose with pubic branch of the inferior epigastric artery.

He classified the variations in the origin of obturator artery from internal iliac artery into 2 groups. He observed the origin from hypogastric artery in 70% of specimens. Among this it

arose from anterior division in 50%. The others were from the main stem, from the posterior division and from superior gluteal artery. Origin from inferior gluteal artery and internal pudendal artery were rare. In 30% of specimens obturator artery arose from external iliac system. In the immense majority of cases, that is in 29 out of every thirty it arose from inferior epigastric artery and in the remaining it arose from external iliac artery distal to inferior epigastric artery or from upper part of common femoral artery.

Origin from external iliac system is due to secondary enlargement of an anastamosis and the diminution or inhibition of the original stem. It has the gradation from normal arrangement to the complete replacement of the obturator artery. Course of obturator artery from inferior epigastric may be on the medial, lateral border or across the crural ring.

Pick, Anson & Ashley (1942)[44] dissected 640 sides and abnormal obturator artery was found to arise from external iliac artery or inferior epigastric artery in 29%. With this abnormal origin, the relationship of the obturator artery to the femoral canal varies (fig 12). More commonly, the abnormal artery tends to parallel the inguinal ligament and passes in front of femoral ring. Less often it passes across the femoral ring, from which position it could be pushed by a femoral hernia, or it turns backward between the iliac vein and femoral ring to run behind the latter. If these relationships hold when a hernial sac is present, it would therefore be impossible to enlarge the neck of the sac without encountering a blood vessel, since the only boundary which is not in contact with the vessel is the posterior one, where the pubis prevents enlargement.

J. L Braithwaite (1952)[24] in his study on 169 specimens observed that the obturator artery is a direct branch of the anterior division of internal iliac artery in 41.4% of cases and arises from inferior epigastric artery in 19.5% (fig 13). There was a similarity in the origin of obturator artery from the superior gluteal artery and the common trunk for inferior gluteal

and internal pudendal artery each found in 10% of instances. In 6.5% of cases it arose from a bifid root, one from an internal iliac source and the other from the external iliac artery. It was given off by the inferior gluteal artery (4.7%), the internal pudendal artery (3.8%), and as a direct branch from the external iliac artery in 1.1%. Of the 74 complete pelves examined, the obturator artery exhibited a similar origin on both sides in 23% (table no. 11).

Morris (1953)[11] observed "abnormal obturator artery" in 37% cases where it originates from inferior epigastric artery or external iliac artery. The proximal relationships are profoundly altered, the vessel coursing near the femoral ring, where it is endangered in operative procedures about the ring.

J.C.B Grant (1957)[7] stated that in 3 out of 10 cases, abnormal obturator artery is related to the medial side of the ring. Out of the 283 sides dissected, he observed the origin of obturator artery in 25.4% from inferior epigastric artery. In 4.6% of cases it arose from both inferior epigastric artery and internal iliac artery.

Hollinshead (1961)[12] stated that in appreciable number of cases the origin of obturator artery from hypogastric is poorly developed, and it arises from inferior epigastric or external iliac artery. This abnormal obturator artery may be in direct contact with femoral ring and hence the neck of the femoral hernial sac.

W. H. Roberts et al., (1967)[28] dissected 79 sides and observed the origin of obturator artery from anterior division in 42 sides, from inferior epigastric artery in 20 sides, from posterior division in 13 sides, from internal iliac artery in 3 sides and external iliac artery in 1 side. Inferior epigastric artery gives off obturator artery as often as any other single source aside anterior division. They also said that the term "aberrant obturator artery" is a misnomer.

Jakubowicz et al. (1996)[45] dissected inferior epigastric artery and obturator artery in 75 lower limbs. In 4% of cases obturator artery originated in common with inferior epigastric artery. Obturator artery also originated from the inferior epigastric artery (2.6%) and from the external iliac artery (1.3%). In 92% of specimens the obturator artery took off from the internal iliac artery at different level.

Gilroy et al. (1997)[46] in their study on 105 specimens found in 70 to 82% of pelvic halves and 83 to 90% of whole pelves have obturator artery, vein or both in variant positions. It is far more common to find a vessel coursing over the pelvic rim at this site than not and they have implications for both pelvic surgeons and anatomists.

Petrenko V.M (2000)[47] stated that definite obturator artery forms as a result of the uneven growth of the anastamosis of external iliac artery and internal iliac artery.

S. Saritha et al (2002)[48] noted a case of bilateral origin of abnormal obturator arteries both arising from inferior epigastric artery. Abnormal obturator artery is found in 30% of all subjects from inferior epigastric artery and also from other sources. But in a portion of cases only, the artery courses the medial side of the femoral ring where it is liable to injury in the operation for femoral hernia.

Narga Nair et al (2002)[49] found an unusual occurrence where a distinct left obturator vein emerged from the obturator canal to terminate in the left internal iliac vein. An accessory obturator vein, emerged from the left obturator canal and coursed superiorly to terminate in the left external iliac vein. The left obturator artery arose from the anterior division of the internal iliac artery and terminated in the parietal pelvic wall (without entering the obturator canal). An accessory obturator artery arose from the left external iliac artery (in addition to its 2 normal branches) and coursed downwards to enter the obturator canal.

Skandalakis (2004)[4] stated that in about 20% of individuals, the obturator arises from the superior gluteal artery. In 33%, an aberrant obturator artery is present, arising from the inferior epigastric. Aberrant obturator is closely related to Gimbernat's ligament. It crosses medial to, lateral to, or directly over the femoral ring. When both normal and aberrant obturator arteries are present with rich anastamosis at the obturator canal it is called "Circle of Death" because of the profuse bleeding that can occur when either vessel is severed.

Sundarapandian S. et al (2004)[50] identified an abnormal obturator artery which was formed by a branch of inferior epigastric (pubic branch) joining a branch of superior gluteal (obturator branch) at the upper part of obturator foramen. Further course of the artery is the same like that of obturator artery.

N Hima Bindu et al (2004)[51] observed in a cadaver with the obturator artery arising from external iliac artery on right side, where as on left side it has its normal course.

Drewes Peter et al (2005)[52] performed dissection of the retropubic space in 15 fresh female cadavers. Vessels crossing the superior pubic rami were inspected for width, course, communications, and relationship to the midline of the pubic symphysis and the obturator canal. Vessels 1 mm or greater in width connecting the obturator vessels and inferior epigastric or external iliac vessels were noted in 10 of 15 (66.7%) cadavers: 9 (60%) had veins, 5 (33.3 %) had arteries, and 4 (26.7%) had both.

EMBRYOLOGY

The most important consideration in the vascular system is its variation. One group of variation represents the persistent fetal forms of circulation. Another group represents individual variations, some of which may be explained developmentally by a study of usual anastamosis.

The umbilical arteries arise when the embryo is less than *1.5 mm long*, about the level where, the fourth cervical mesodermal somite is developed at a later stage. They develop from the plexus formed, on the lateral walls of caudal part of the primitive gut, by anastamosis of some of the most caudally situated ventral or vitelline branches of the primitive dorsal aorta.

This origin of the arteries are gradually moved tailwards as the embryo grows, until eventually, they spring from primitive dorsal aorta *opposite the 23rd body somite, which is the fourth lumbar segment.* As each umbilical artery passes from its origin to its body stalk, it lies to the medial side of pronephric duct. The ventral origin is however, but temporary, as by the time embryo has attained a length of 5 cm, a new vessel has arisen on each side from the lateral part of the caudal end of the aorta. This new vessel passes ventrally to the lateral side of the mesonephric duct, and then unites on a plane ventral to the aorta, with the primitive umbilical artery of the same side (fig 14).

After the union, the ventral origin of umbilical artery disappears, and the primitive umbilical artery then arises from the side of caudal end of aorta. From the newly formed vessel, which now constitutes the only origin of the umbilical artery, the *inferior gluteal artery*, which is the primitive main artery of lower limb, arises.

At a later period, and at a more dorsal level, a second branch arises from the dorsal root of origin of umbilical artery; which becomes the external iliac artery. The portion of umbilical arterial stem which lies dorsal to it becomes common iliac and more ventral part, which descends to the true pelvis, becomes internal iliac artery. But that portion of the umbilical artery, which runs along the side of the true pelvis to the ventral wall of the abdomen, then to the umbilicus and through the umbilicus to the placenta is still called the umbilical artery.

After birth, the greater part of intra abdominal portion of umbilical artery atrophies and is converted into medial umbilical ligament; but from the pervious part which lies in the pelvis springs the *superior vesical artery*[7]. The primary axial artery of lower limb is *inferior gluteal artery* which springs from secondary umbilical artery. The main remnants of primary axial artery present in the adult are inferior gluteal artery and its sciatic branch.

Keiichi Akita (2003)[53] quoted that internal iliac artery is embryologically consisted of two main trunks: the medial umbilical ligament (superior vesical artery) and inferior gluteal artery. Most of the branches originate from the two trunks and the junction between them. The intrapelvic branches run caudalward.

The true morphological position of internal iliac artery is not yet defined. They are parts of secondary roots of umbilical artery; the branches distributed to the gut represent the splanchnic vessels, homologous with ordinary splanchnic branches of primary aorta and parietal branches are possibly, the homologues of inter segmental arteries[7].

The definitive obturator artery forms as a result of uneven growth of the anastamosis between internal iliac artery and external iliac artery which is connected with the peculiarities of regional organogenesis[47]. All gradations may be found between normal arrangement and complete replacement of the original intrapelvic portion of the obturator artery by the pubic anastamosis[10].

MATERIALS AND METHODS

STUDY MATERIALS:

A. Cadaveric Study

1. Thirty eight adult specimens composed of 32 male and 6 female pelvic halves.
2. Twelve fetal specimens composed of 8 male and 4 female fetal pelvic halves.

B. Radiological study

1. Adult pelvic angiogram
2. Fetal pelvic angiogram

Specimen Collection:

Adult specimens were obtained from 19 embalmed adult cadavers of age group 50 to 80 years. Pelvis was separated by sectioning transversely at the level of $L_4 - L_5$ articulation. To enable visualization of small arteries clearly, red oxide solution was prepared and injected into the internal iliac artery in 10 specimens. Other specimens were left uninjected with the preparation. Then, for the sake of convenience of doing dissection, the pelves were bisected with the help of body cutting machine.

Fetal specimens were obtained from 6 dead unclaimed fetuses, all from 7 to 9 months of gestational age, from the Institute of Obstetrics and Gynecology, Madras Medical College. Fetal embalming was done and the fetuses were preserved. Then transverse sections were made manually at the level of upper border of iliac crest. Then the pelves were bisected and kept ready for dissection. Lower limbs were not detached from the pelves to aid doing dissection.

Adult pelvic angiograms of 10 patients who underwent the procedure in Barnaud Institute of Radiology, Government General Hospital were collected.

Fetal angiography was done on three fetal specimens obtained from the Institute of Obstetrics and Gynecology – Madras Medical College, after injecting radio opaque dye into the pelvic vessels.

METHODS OF STUDY

A. *CADAVERIC STUDY:*

Adult specimens:

1. Dye Injection method
2. Direct Dissection method

Dye Injection method:

The dye used for injection was prepared from red oxide 100 gm; bull's fat 200 gm; groundnut oil 100ml and turpentine oil 75 ml. The first three components were mixed together, boiled and filtered. Turpentine oil was then added.

The pelves to be injected with the dye were washed. The peritoneum was gently stripped off in the prevertebral region in front of L_5 and S_1. The openings of common iliac arteries were identified. Each artery was further traced distally till it divides into internal iliac artery and external iliac artery. External iliac artery was ligated at its origin to avoid the dye from spilling out through femoral artery. A 30 ml glass syringe with polythene cannula attached at its tip was filled with normal saline. Saline was injected into common iliac artery and aspirated out. This was repeated till the returning fluid was free of clot and debris. All the five pelves to be injected with the dye were prepared by the same procedure. The dye was injected into common iliac artery rapidly before it solidified. Injection was continued till the

dye seeped out through the small vessels at the margin of the sectioned pelves. The same procedure was repeated on the other side also. The specimen was preserved in 10% formalin solution. After a period of two days, pelves were bisected using body cutting machine and dissection was carried out.

Direct dissection method:

The lumen of cut end of common iliac artery was identified. Peritoneum over the iliopsoas was gently stripped off. Ureter is usually just beneath this layer and was also stripped away from its position by this step. The relationship of ureter to internal iliac artery was noted.

Common iliac artery was traced to find external iliac extending in line with common iliac artery towards the inguinal ligament and internal iliac directed towards the pelvic cavity. The level of bifurcation of common iliac artery into external and internal iliac artery was noted.

Common iliac vein, formed by the union of external iliac vein and internal iliac vein was seen in close proximity in a plane just posterior to the arteries. The relationship of internal iliac vein to internal iliac artery was observed and noted.

After observing this relationship, ureter was lifted away from the artery. The tributaries of internal iliac vein along with the main trunk were removed in toto taking care not to injure the branches of internal iliac artery. The length of internal iliac artery from its origin to the level of its bifurcation into anterior and posterior divisions was measured.

With careful dissection internal iliac artery was traced to its two divisions or to its branches if it does not divide into two trunks. From each division, both parietal and visceral branches

were traced. Parietal branches were traced till they exit from the pelvic cavity. Visceral branches were followed till they reach their destination and their origins noted.

External iliac artery was also traced distally till its exit behind the inguinal ligament to look for the presence of the aberrant obturator artery arising either from inferior epigastric artery or external iliac artery directly. In case of abnormal obturator artery, its origin was noted and the entire course of the artery till it reached the obturator foramen was traced. Its relationship to the femoral ring was also noted. After thoroughly clearing the fascia, pictures were taken. The specimens were preserved in 10% formalin solution.

Fetal specimens:

Dissection of internal iliac artery in fetal specimens was a tedious procedure due to the extremely small branches in the fetus. Same procedure as done in adult dissection was repeated but with utmost gentleness and care and as many branches as possible were dissected and pictures were taken.

B. *RADIOLOGICAL STUDY:*

Adult Pelvic Angiogram:

Pelvic angiography done in Barnaud Institute of Radiology, Government General Hospital, was observed for 10 patients who underwent the procedure for various reasons, both prophylactic and therapeutic purposes. The angiogram pictures were collected.

The procedure was done by Seldinger's technique. The examination of the patient was performed under local anesthesia. After the anaesthetic agent infiltrated the subcutaneous tissues, a small skin incision was made over the femoral artery just below the midinguinal point. The artery was entered via a single entry puncture. The arterial puncture site was dilated by introduction of a vessel dilator over the guide wire. Guidance systems altering the

curvature of the catheter tip by means of tip deflector is used to help engage the desired vessel.

The entire procedure was done under fluoroscopic guidance. Through femoral artery, external iliac artery was entered. After bending the catheter tip internal iliac artery was entered. Radiopaque dye (Injection Trazograf 76%) was injected and serial radiological pictures were taken.

Two patients underwent *'Uterine artery embolization'* as a therapeutic procedure for fibroid uterus. This was performed by selective catheterization of uterine arteries. Vascularization of the tumour was studied. Gelfoam sponges were injected into the feeding artery on both the sides.

Fetal Pelvic Angiogram:

Three fetuses were obtained from Institute of obstetrics and Gynecology. The fetuses were embalmed. Then a transverse section was made at the level of upper limit of iliac crest. The pelvis with intact lower limbs was washed thoroughly with water. Normal saline was injected through common iliac artery and aspirated completely. This procedure was repeated till the flushed out saline was clear of clot and debris. An incision was made just below the midinguinal point and femoral artery dissected out. Femoral artery was ligated. This was done to avoid the dye from overflowing into femoral artery and its branches.

The specimen was then preserved in 10% formalin and mobilized to Radiology department. The radio opaque dye (Injection Trazograf 76%) about 2ml was injected through common iliac artery bilaterally using a syringe and radiological pictures were taken. The branches of internal iliac artery were noted in the obtained angiogram.

OBSERVATION

A. DISSECTION METHOD:

IN ADULTS

The findings of dissection of thirty eight specimens comprised of adult cadaveric pelvic halves are summarized as follows under the following headings:

1. Length of the internal iliac artery
2. Extent of internal iliac artery
3. Relationship with ureter and internal iliac vein
4. Branches and Branching pattern of the internal iliac artery
5. Obturator artery

1. Length of internal iliac artery

The length of internal iliac artery is measured in those specimens which show clear cut termination of internal iliac artery into anterior and posterior trunks which is found in 30 specimens. The length of internal iliac artery ranges from the minimum value of 2.3 cms (pic 2) to the maximum length of 7.1 cms (pic 3). Out of this, in majority of specimens (2/3 rd of specimens) the length of internal iliac artery is between 2.5 to 4.2 cms. Mean length is found to be 3.7 cms (table no. 12).

2. Extent of internal iliac artery

The *origin* of internal iliac artery is found to be at the level of lumbosacral articulation (pic 4) in 28 specimens (73.6%) and it is above that level (pic 5) in 10 specimens (26.4%). The findings are given in table no.13.

Among the 30 specimens, where internal iliac artery divide into anterior and posterior trunks, the *level of bifurcation* into anterior and posterior divisions is found to be at the level of upper border of greater sciatic notch in 20 specimens (66.7%) while it is at a highly variable position between lumbosacral articulation and greater sciatic notch in 10 specimens (33.3%).

3. Relationship with ureter and internal iliac vein

In all the thirty eight specimens, internal iliac artery is crossed anteriorly by ureter (pic 6) which separates the artery from peritoneum.

Internal iliac vein is situated posterior to the artery (pic 7). Common iliac vein and termination of external iliac vein are posterolateral to internal iliac artery separating it from psoas major and obturator nerve.

4. Branches and Branching pattern of internal iliac artery :

a. Division of internal iliac artery:

In the present study, internal iliac artery terminates by dividing into anterior and posterior divisions (pic 8) in 30 specimens (78.9%) *and in 8 specimens (21.1%) it terminates by dividing into its principal branches directly without dividing into two divisions* (pic 9).

Among the 30 specimens, which divide into anterior and posterior divisions, the branches that arise from the anterior division are *parietal* branches namely, inferior gluteal, internal pudendal, obturator artery, and *visceral* branches namely superior vesical, inferior vesical, middle rectal artery; in females, in addition uterine and vaginal artery (instead of inferior vesical in males). The branches observed to arise from posterior division are superior gluteal, iliolumbar, and lateral sacral artery.

However some arteries are noted to deviate from the usual origin as noted below. In the present study, out of the 30 specimens,

a. *Inferior gluteal artery usually a branch of anterior division is noted to arise from posterior division* (pic 10) *in 6 specimens (20%).*
b. *Obturator artery, usually a branch of anterior division is found to arise from posterior division* (pic 11) *in 2 specimens (6.7%)*
c. *Middle rectal artery which is usually a branch of anterior division is found to arise from posterior division* (pic 10) *in 2 specimens (6.7%)*
d. *Lateral sacral artery, usually a branch of posterior division is found to arise from anterior division* (pic 12) *in 1 specimen (3.3%)*

b. Branches from the main stem of internal iliac artery before its division into anterior and posterior divisions:

The main vessel usually does not give rise to any significant named branches while all of them arise from its divisions. In the present study, among the 30 specimens where internal iliac artery divide into anterior and posterior divisions 13 of them reveal no branches from internal iliac artery trunk *(43.3%).*

However in 17 cases (57.7%), even before the main artery bifurcates into its subdivisions, it is found to give rise to the following branches.

Iliolumbar artery which is usually a branch of posterior division is found to originate from internal iliac artery as separate branch (pic 13) *in 5 cases(16.7%); lateral sacral artery which is also usually a branch from posterior division takes origin from internal iliac artery as separate branch* (pic 31) *in 6 cases(20%); both iliolumbar artery and lateral sacral artery arise as separate branches in 1(3.3%) and as a common trunk in 2 specimens(6.6%); iliolumbar artery separately and lateral sacral artery with middle rectal artery as a*

common trunk in 1 specimen(3.3%); Iliolumbar artery and middle rectal artery as common trunk in 1 specimen(3.3%); Lateral sacral artery and middle rectal artery as separate branches (pic 14) *in 1 specimen(3.3%) (Table no. 14).*

c. Inferior gluteal artery:

In the present study, inferior gluteal artery arises as a branch of anterior division in common with internal pudendal artery (pic 15) in 24 out of 38 specimens (63.2%), of which it is also in common with obturator artery (pic 16) in a single specimen (in another 5 specimens obturator emerges from the common trunk for internal pudendal and inferior gluteal artery).

Inferior gluteal artery arises from internal iliac as a direct branch (pic 9) *in 5 pelvic halves, in common with iliolumbar* (pic 17) *in 1 specimen and in common with middle rectal* (pic 18) *in 2 cases. In 6 specimens, it arises from posterior division, in common with superior gluteal of which it is also accompanied by the origin of middle rectal* (pic 10) *in 2 cases and by lateral sacral artery* (pic 36) *in 1 specimen. (Table no. 15)*

***d. Internal pudendal artery*:**

In the present study internal pudendal artery arises from anterior division in *30 cases (78.9%),* out of which it is in common with inferior gluteal (pic 15) in *24 cases (63.2%)*; with inferior vesical (pic 10) in *3 cases (7.9%);* and as a direct branch from anterior division (pic 20) in 3 specimens. Among the 24 cases of its origin from the common trunk with inferior gluteal, the bifurcation of common trunk occurs below the pelvic floor (pic 2) in 1 specimen. Out of the 30 specimens, internal pudendal artery is in common with middle rectal artery in 25 specimens(pic 19).

Internal pudendal artery originates as a branch from internal iliac artery (pic 21) *in 8 specimens which includes its origin in common with middle rectal artery* (pic 9) *in 3*

specimens, with inferior vesical artery (pic 18) *in 1 case and in common with obturator artery in 1 specimen (Table-16).*

e. Superior vesical artery:

In the present study, in the entire thirty eight specimens superior vesical artery arise from umbilical artery which is the continuation of internal iliac artery beyond the principal branches. The number of branches varies from one to three (pic 15, 22, 10) (Table no. 17).

f. Inferior vesical artery:

In the present study, the origin of inferior vesical artery is noted in 32 male specimens, (it is replaced by vaginal artery in the other 6 female pelvic halves). It arises from anterior division in 24 specimens (75%) out of which it arises as a direct branch (pic 2) in 5 specimens; from umbilical artery (pic 23) in 15 specimens; and from internal pudendal artery (pic 10) in 4 specimens. *Inferior vesical artery originates from internal iliac artery* (pic 24), *as a separate branch in 2 specimens; in common with internal pudendal artery* (pic 18) *in 1 specimen and from umbilical artery* (pic 17) *in 5 specimens (Table no. 18).*

g. Middle rectal artery:

In the present study, in 23 out of 38 specimens (60.5%) middle rectal artery originates from anterior division which includes its origin in common with internal pudendal (pic 25) in 13; with inferior gluteal (pic 16) in 2; with common trunk for both arteries (pic 2) in 8 specimens.

In two specimens it arises from posterior division (pic 10) *in common with inferior gluteal artery. In three specimens, from main stem of internal iliac artery* (pic 14) *before it divides*

into anterior and posterior divisions. Among the eight specimens where internal iliac artery does not end by dividing into 2 trunks, middle rectal artery arises in common with other branches-internal pudendal artery (pic 9) *in 5, inferior gluteal artery* (pic 18) *in 2 and obturator in 1 specimen.*

In two specimens, middle rectal artery is absent. Two middle rectal arteries (pic 25) *are found in a specimen, where both the branches originate from internal pudendal artery (Table no.19).*

h. Uterine artery:

In the present study uterine artery is studied in six female pelvic halves. It is found to arise from the anterior division (pic 26) in 3 specimens and from the umbilical artery (pic 25) in 3 specimens. It passes at first downwards and medially then along the base of broad ligament to the neck of the uterus. Close to the neck of the uterus it crosses the ureter (pic 27).

i. Vaginal artery:

In the present study, in these 6 specimens vaginal artery is found to arise from umbilical artery (pic 25) in *4 cases;* in common with uterine artery (pic 27) in a *single specimen* and from anterior division in a single case (Table no.20).

j. Superior gluteal artery:

In the present study superior gluteal artery arises from posterior division in 30 specimens (78.9%) out of which it is the single terminal branch (pic 16) in 23 specimens; in common with inferior gluteal artery (pic 10) in 6 cases.

Superior gluteal artery arises directly from internal iliac in 8 out of 38 specimens (21.1%), where it is accompanied by the following branches namely lateral sacral (pic 9) in one;

iliolumbar artery and lateral sacral artery (pic 29) in four; iliolumbar artery, lateral sacral artery and obturator artery in one; lateral sacral artery and obturator artery (pic 21, 28) in one specimen (Table no. 21).

k. Iliolumbar artery:

Among the 30 specimens, where internal iliac artery divides into anterior and posterior branches, iliolumbar artery arises as a branch from the main stem before division (pic 13) in 10 specimens; from posterior division (pic 30) in 20 specimens. Among the 8 specimens, where the internal iliac does not divide into 2 trunks iliolumbar takes origin in common with superior gluteal (pic 29) in 5 specimens, (accompanied by lateral sacral in 4 and by obturator artery in one specimen); with inferior gluteal (pic 17) in 1; and as a direct branch (pic 18) in 2 specimens (Table no.22).

l. Lateral sacral artery:

Number of lateral sacral arteries

Among the 38 specimens lateral sacral artery arises as a single artery which divides into 2 branches (pic 31) *in 23 sides; 2 arteries* (pic 16) *in 11 sides and as 3 arteries* (pic 25) *in 4 specimens (Table no.23).*

Origin of lateral sacral artery

In the present study, out of the 30 specimens where internal iliac artery divides into 2 divisions lateral sacral artery arises from posterior division (pic 30) in 18 cases (12 single, 5 double and 1 triple arteries); from anterior division in common with inferior gluteal artery (pic 12) in 1 specimen (single); from main stem before its division (pic 31) in 8 specimens

(7 single, 1 double); from both main stem and posterior division (pic 2) in 3 specimens (2 vessels from posterior division and 1 from main stem before division).

Among the 8 specimens which do not end as 2 divisions, lateral sacral artery arises in common with superior gluteal artery (pic 29) in 7specimens (3 single, 4 double arteries) and from internal iliac artery (pic 18) directly in one specimen (double arteries) (Table no.24.)

m. Branching pattern of internal iliac artery:

Among the parietal branches of internal iliac artery, the large caliber vessels namely, superior gluteal artery, inferior gluteal artery and internal pudendal artery show sufficient regularity in the origin to enable them to be grouped into *definite branching pattern as was explained by Adachi. This pattern is based only on the grouping of these large vessels, irrespective of whether internal iliac artery divides into anterior and posterior divisions or not. The branching pattern is also irrespective of the origin of these three vessels in common with any other smaller branches.*

On the basis of *Adachi's classification*, the branching of the internal iliac artery based on the origin of the above said principal parietal branches namely superior gluteal artery, inferior gluteal artery and internal pudendal artery is found to be of the following patterns in the present study:

i. In **60.6%** of cases (23 specimens) superior gluteal artery arises separately from internal iliac artery and a common trunk for inferior gluteal artery and internal pudendal artery divides proximal to the pelvic floor [Type Ia] (pic 32).

ii. In **2.6%** of cases (1 specimen) superior gluteal artery arises separately from internal iliac artery and a common trunk for inferior gluteal artery and internal pudendal artery divides distal to the pelvic floor [Type I_b] (pic 33).

iii. In **15.8%** of cases (6 specimens) internal pudendal artery arises separately from internal iliac artery while inferior gluteal artery and superior gluteal artery arise by a common trunk which divides proximal to the pelvic floor [Type IIa] (pic 34).

iv. In **21.1%** of the cases (8 specimens) the three branches namely inferior gluteal, superior gluteal and internal pudendal artery arise separately from the internal iliac artery [Type III] (pic 35).

5.Obturator Artery:

a. Origin of obturator artery:

In the present study, obturator artery is found to arise from internal iliac artery or its branches in 57.9% and in the remaining from external iliac artery or its branch (Table25).

Among its origin from internal iliac artery, anterior division (pic 20) scores the highest incidence of 23.7% (9 cases) and from the common trunk for inferior gluteal artery and internal pudendal artery (pic 5) in 13.2% (5 cases); superior gluteal artery (pic 28) is next common with the incidence 5.3% (2cases) and from the umbilical artery (pic 36) in 5.3% (2 cases). Other origins of obturator artery noted are, from inferior gluteal artery (pic 16) in 2.6% (a single case); from internal pudendal artery (pic 4) in 2.6% (single case); from the posterior division (pic 11) in 5.3% (2 cases)

b. Abnormal Obturator artery:

In 36.8% of specimens obturator artery is found to arise from external iliac artery or its branch. In 5.3% of specimens (2 cases) it arises from the external iliac artery trunk (pic 37) and in 31.6% (12 cases) it arises from inferior epigastric artery (pic 38). It is interesting to note that among the six female pelvic specimens studied, four of them reveal abnormal Obturator artery and all of them take origin from inferior epigastric artery.

c. Bilateral similarity:

Among the 19 whole pelves studied, 10 of them show abnormal obturator artery. It is found to be bilateral in four (21.1%) and unilateral in six specimens (31.6%).

d. Origin from 2 roots:

Two specimens (right and left halves of a female pelvis) reveal origin of obturator artery from 2 roots. In one specimen, there was an origin from superior gluteal and another origin from inferior epigastric artery. In the other, there was an origin from posterior division and another from inferior epigastric artery. Then the two roots unite at the upper margin of obturator foramen and continue as obturator artery through the foramen (pic 40).

e. **Relation to femoral ring**:

Among 12 out of 14 cases with abnormal obturator artery and both the specimens with double origin (87.5%) the abnormal obturator artery has its course lateral to the femoral ring (pic 39). Two cases (12.5%) have the artery running medial to the femoral ring and hence along the margin of lacunar ligament (pic 38).

IN FETUSES

Fetal specimens composed of 12 pelvic halves of unclaimed dead fetuses of 7 to 9 months of gestational age are dissected and the following observations are made. Fetal internal iliac artery appears to be in line with the common iliac artery in contrast to that observed in adult vessels. It continues as the umbilical artery which ascends along the sides and apex of bladder to enter the anterior abdominal wall till it reaches the umbilicus. The branching pattern and the origin of obturator artery are studied.

a. Branches and Branching pattern:

In the present study, twelve fetal specimens are dissected with great difficulty and the branches identified. They are grouped together and observation listed as follows.

In 8 specimens (66.7%), two large trunks arise from internal iliac artery (pic 42). Even before these trunks, iliolumbar artery arises singly in 1specimen; common trunk for iliolumbar artery and lateral sacral artery arises in 2 specimens; lateral sacral artery and a common trunk for iliolumbar artery and obturator artery arises in a single case from internal iliac artery.

The *posterior trunk* continues as superior gluteal artery accompanied by iliolumbar and lateral sacral artery in 2 cases (also in common with obturator artery in one), with lateral sacral artery in 2 cases (also in common with obturator artery in 1 specimen).

The *anterior trunk* gives off a common trunk for internal pudendal artery and inferior gluteal artery {also accompanied by middle rectal alone in 2; obturator (pic 43) in one; both in one specimen}. The other twigs from anterior division are noted to be superior vesical in all the cases, uterine artery (pic 44) in 3 female specimens, vaginal artery in 2 specimens, and inferior vesical artery in 5 specimens. In 2 out these 8 specimens, the division of the common trunk for internal pudendal artery and inferior gluteal artery occurs outside the pelvic cavity (pic 45).

In 3 specimens (25%), superior gluteal artery arises in common with lateral sacral artery and iliolumbar artery (also with obturator artery in one) as the first branch from internal iliac artery (pic 46). Inferior gluteal artery arises as the next branch, also accompanied by obturator artery in one and by middle rectal artery in one specimen. Internal pudendal artery is the next branch also accompanied by obturator artery in one and vaginal artery in one specimen. Inferior vesical artery in 2 specimens and superior vesical artery in all three

specimens are the next branches. In 1 female specimen, uterine artery arises just before the origin of superior vesical from internal iliac artery.

In one specimen (8.3%), inferior gluteal and superior gluteal artery arise from a common trunk also accompanied by small branches namely lateral sacral, iliolumbar, and middle rectal artery. Obturator artery arises in common with inferior vesical artery. Internal pudendal artery appears as a distinct branch. Superior vesical artery is the last branch (pic 47).

b. Origin of obturator artery:

Obturator artery takes origin from anterior trunk (pic 43) in3 specimens (25%); from the posterior division (pic 45) in 3 specimens (25%); from the main stem in 2 specimens (16.6%); in common with superior gluteal artery (pic 46) in 1(16.6%); in common with inferior gluteal artery in 1(16.6%); in common with internal pudendal artery in 1 specimen (16.6%); in common with inferior vesical artery in 1 specimen (16.6%).

B. RADIOLOGICAL STUDY

i. Adult pelvic angiogram:

The pelvic angiogram done for various reasons were collected and the different branches of internal iliac artery traced as follows (pic 48):

1. The posterior trunk early in its course, gives rise to 1 or 2 lateral sacral arteries which in turn furnishes segmental branches to sacral foramina.
2. Next branch from posterior trunk is iliolumbar with its iliac and lumbar ramifications.
3. Posterior trunk continues in a transverse course through the greater sciatic notch

as superior gluteal artery.

4. Obturator artery traced back from its terminal branches encircling the obturator foramen.

5. Internal pudendal artery usually crosses obturator foramen inferior to obturator artery and terminates in scrotal or labial region as fine branches.

6. Inferior gluteal originates with superior gluteal or internal pudendal artery with laterally descending course parallel to the axis of femoral neck, often projected over the bone.

7. Uterine artery comes off high on the anterior trunk and has coiled terminal azygos branches in the uterus and vagina.

Though the arteries could be identified by radiological method and is of immense use for various procedures, the branching pattern cannot be clearly delineated. This is because the origins of the vessels are not clearly made out in angiogram pictures.

"*Uterine artery embolisation"* was observed in 2 patients the indications being fibroid uterus. On follow up, the patients showed decreased symptomatology and reduction in the size of the fibroid volume of upto 80%.This study was described to reveal one of the important uses of pelvic angiogram (pic 49).

ii. Fetal Angiogram:

Radio opaque dye was injected into internal iliac artery of 3 fetal pelves and the branches are noted. It is obvious from the picture that internal iliac artery is the continuation of common iliac artery and is patent through the umbilicus unlike in adults where the lumen of the artery is obliterated beyond the superior vesical branches to the bladder .The branches are identified and shown in the picture 50.

DISCUSSION

1. Length of internal iliac artery

Gray (1901)[5] stated that the minimum length of internal iliac artery is 1.25 cm, while **Bergman** (1988)[8] found it to be 1.2 cm.

In the present study (2007) the minimum length of internal iliac artery is 2.3 cms, which more than that of Gray and Bergman.

The maximum length of internal iliac artery was noted by **Gray** and **Bergman** to be 7.5 cm while in the **present study** it is 7.1 cm. which is almost similar to the findings of authors.

Gray (1901)[5] stated that the length of internal iliac artery is in 2/3rd of cases 2.5cm.to 3.75cm.In the **present study,** in most of the cases (more than 2/3rd) the length of internal iliac artery ranges from 2.5 cms to 4.2 cms which is almost similar to that of Gray.

J.E. Frazer (1937)[6] and **J.C.B. Grant** (1951)[7] stated the length of internal iliac artery as about 3.75 cm. In the **present study,** the mean length of internal iliac artery is 3.9 cm which correlates with the findings of authors.

The ***Clinical importance*** underlying the measurement of length of internal iliac artery is that the application of a ligature to internal iliac artery may be needed in cases of aneurysms or hemorrhage affecting one of its branches. The degree of facility of applying a ligature to this vessel will mainly depend on its length. If the vessel is short, then it is deeply seated in the pelvis. On the contrary, if artery is longer it is found partly above the cavity. If artery is short, it would be preferable to apply a ligature to the common iliac artery or upon external iliac artery and internal iliac artery at their origin[5].

2. Extent of internal iliac artery

Gray (1901)[5] stated that internal iliac arteries arise at the point of bifurcation of common iliac artery which in 2/3rd (66.7%) of the cases is between last lumbar vertebrae and upper border of sacrum. **George A Piersol** (1930)[10], **Morris** (1953)[11] and **Grant** (1957)[7] stated that internal iliac artery arises from common iliac artery at the level of lumbosacral joint and passes almost directly downwards in front of sacroiliac articulation into the pelvis.

In the present study (2007), internal iliac artery takes origin *at the level* of lumbosacral joint in 73.6% of specimens which correlates with the findings of all the above authors.

Gray (1901)[5] found that in1/8th (12.5%) internal iliac artery originates *above the level* of lumbosacral joint while in the **present study** it is 26.4% which is slightly more than the statement of Gray. While **Gray** found the origin to be *below this level* in 16.7%, none of the specimens revealed such origin *in the **present study*** as against the finding of Gray (chart 1).

Gray[5]**, Piersol**[10] and **Grant**[7] stated that the internal iliac artery passes downward to the upper margin of great sacrosciatic foramen and divides into anterior and posterior trunks.

In the present study the *level of bifurcation* into anterior and posterior divisions is found to be at the level of upper border of greater sciatic notch in 66.7% which correlates with the statement of these authors.

Ronald A. Bergman (1988)[8] stated that the division may occur anywhere between the pelvic brim and the upper border of the sacrosciatic foramen while in the **present study** such variable division is found in 33.3%.

The **clinical significance** of knowing the extent is that, it determines the length of the internal iliac artery. So, a low origin or a higher termination leads to short internal iliac artery and hence surgically significant as already stated.

3. Relationship of internal iliac artery with vein and ureter

Gray (1901)[5], **Frazer** (1937)[6], **J.C.B. Grant** (1951)[7] and **Morris** (1953)[11] stated that internal iliac artery is related in front to ureter.

George A. Piersol (1930)[10] said that ureter, crosses the vessel obliquely from without inward and downward anterior to internal iliac artery.

In the **present study** internal iliac artery is found to be related *anteriorly to ureter* which separates the artery from peritoneum, similar to the statement of these authors.

Gray (1901)[5] stated that internal iliac artery is related behind to internal iliac vein.

Frazer (1937)[6] quoted that internal iliac artery is related posteriorly to internal iliac vein and common iliac vein while, **Morris** (1953)[11] stated that internal iliac artery is related laterally to common iliac vein and posteriorly to hypogastric vein.

In the **present study**, internal iliac vein is situated posterior to the internal iliac artery. Common iliac vein and termination of external iliac vein are posterolateral to internal iliac artery which correlates with the statement of the above said authors.

The **Clinical Importance** of knowing this relationship is that, while applying ligature to internal iliac artery in aneurysm or hemorrhage, care must be taken to avoid the vein and the ureter. The ureter be carefully identified and observed to avoid its inadvertent damage. The increasing repertoire of gynecological surgical procedures emphasizes the importance of understanding anatomy to prevent and manage lower urinary tract misadventures. The needle should be passed from within outwards while ligating internal iliac artery to avoid damage to the internal iliac vein. If this is done, bleeding from the tear is difficult to control. Internal iliac vein is closely related to the artery and should not be tied. If done, this will increase the venous pressure in the uterus and make bleeding from it worse.

4. Branches and Branching pattern of internal iliac artery

a. Division of internal iliac artery:

J.E. Frazer (1937)[6] classified the branches of internal iliac artery as two terminal divisions, anterior and posterior of which some are parietal in distribution while others are visceral.

Grant (1957)[7] said that the branches are classified as parietal and visceral. The branches from posterior division are all parietal namely iliolumbar artery, lateral sacral artery and superior gluteal artery. The parietal branches from anterior division are obturator, internal pudendal, and inferior gluteal arteries. The visceral branches from anterior division are umbilical, superior vesical artery, middle rectal artery, and inferior vesical artery in male and uterine and vaginal artery in female.

Hollinshead (1961)[12] said that the posterior trunk gives origin to iliolumbar, lateral sacral, and superior gluteal artery, while the anterior trunk gives rise to all the visceral branches, including umbilical artery, and to obturator, internal pudendal and inferior gluteal arteries.

Skandalaki (2004)[4] and **Susan Standring** (2005)[39] mentioned that internal iliac artery divides into anterior trunk and posterior trunk.

In the **present study** (2007), internal iliac artery terminates by dividing into anterior and posterior divisions in 30 specimens (78.9%) *which correspond to the statement by all the above said authors.*

Morris (1953)[11] classified the branches of internal iliac artery into parietal and visceral sets. He also stated that the so called anterior division and posterior division may not exist at all.

Grant (1957)[7] said that all the branches of internal iliac artery may be given off separately from a single undivided parent trunk.

Hollinshead (1961)[12] said that the division of hypogastric artery into two may not be clear cut, and the branches which arise from anterior and posterior trunks may vary considerably.

Ronald A. Bergman (1988)[8] stated that in some cases the branches arise without the artery dividing into an anterior and posterior division.

Skandalaki (2004)[4] noted one variation where, the branches can arise as 'spray' of vessels with no distinct formation of anterior and posterior divisions.

In the present study, *in 8 specimens (21.1%) internal iliac artery terminates by dividing into its principal branches directly without dividing into two divisions as stated by Morris, Grant, Hollinshead and Skandalaki.*

Hollinshead[12] also said that the posterior division instead of terminating as superior gluteal artery may end by dividing into superior gluteal artery and inferior gluteal artery and sometimes obturator artery may arise from posterior division.

Ronald A. Bergman (1988)[8] stated that the branches of the anterior and posterior divisions of the internal iliac may exchange origins.

In the present study (2007), among these 30 specimens, Inferior gluteal artery, Obturator artery, Middle rectal artery usually branches of anterior division are noted to arise from posterior division in 20%, 13.3%, and 6.7% respectively. Lateral sacral artery, usually a branch of posterior division is found to arise from anterior division in 3.3%. *The findings of exchange of origin of vessels correlate with the quotings of Bergman and Hollinshead.*

b. Branches from the main stem before its division into anterior and posterior divisions:

Ronald A. Bergman (1988)[8] said that one or more branches originate above the division of internal iliac artery into its 2 trunks

In the **present study** *in 53.3% of specimens, even before the main artery bifurcates into its divisions, it is found to give rise one or two branches as stated by the author.*

Poynter (1922)[20] stated that lateral sacral artery originate from internal iliac artery directly in 22% of cases.

In the **present study**, *similar origin of* lateral *sacral artery is found in 33.3%* (either singly or with other branches*) which is slightly higher than Poynter's finding.*

George A. Piersol (1930)[10] stated that iliolumbar artery arises from the main stem of internal iliac artery before it divides into anterior and posterior trunks.

In the **present study** *similar origin of iliolumbar artery is noted in 26.6%.*

J. C. B. Grant (1957)[7] said that the main stem of internal iliac artery may give origin to accessory renal or ureteric branch.

Hollinshead (1961)[12] said that before internal iliac artery ends in its terminal branches, the hypogastric artery may give off a twig to the pelvic portion of ureter.

In the ***present study****, no accessory renal or ureteric branch was encountered to arise from the main stem as found by Grant and Hollinshead*

c. Inferior gluteal artery:

Parson and Keith (1897)[14] found that in 75% of cases inferior gluteal artery arose from the anterior division.

Piersol (1930)[10], **Skandalaki (**2004)[4] and **Susan Standring** *(2005*)[39] said that inferior gluteal artery is the larger of the 2 terminal branches of anterior division.

Morris: (1953)[11] and **Grant** (1957)[7] said that inferior gluteal artery arises from a common trunk with internal pudendal artery.

In the **present study** (2007) inferior gluteal artery originates from anterior division in common with internal pudendal in 63.2% which is in accord with the authors.

Parson and Keith (1897)[14] found that, inferior gluteal artery originates from the posterior division in 21.4% while **Skandalaki (**2004)[4] said that inferior gluteal artery arises from posterior division in a significant number of cases.

Piersol (1930)[10], **Morris** (1953)[11] and **Grant** (1957)[7] have mentioned about origin of inferior gluteal artery in common with superior gluteal artery.

In the **present study** (2007) it originates from posterior division in common with superior gluteal artery in 15.8% which coincides with these authors.

The origin of inferior gluteal artery directly from internal iliac artery was noted by ***Parson and Keith*** (1897)[14] in 1.8% and also mentioned by Piersol and Morris.

In the **present study** (2007) it originates from internal iliac artery in 21.1% as noted by these authors though it is more than Parson's study. *(Table no. 26)*

d. Internal pudendal artery:

Piersol (1930)[10], **Skandalaki (**2004)[4] and **Susan Standring** *(2005*)[39], said that internal pudendal artery is the terminal branch of anterior division.

In the **present study** (2007) internal pudendal artery arises from anterior division in *78.9% which corresponds to Susan, Piersol, and Skandalaki.*

Piersol (1930)[10] stated that internal pudendal artery is a branch from anterior division; occasionally originates with inferior vesical artery, middle rectal artery.

In the **present study** *in 15.8% it is in common with inferior vesical artery and with middle rectal artery in13.2% which correlates with Piersol.*

Grant (1957)[7] said that internal pudendal artery takes origin in common with inferior gluteal artery and similar origin is noted in the **present study** in 63.2%

Ronald A. Bergman (1988)[8] said that internal pudendal artery may arise in common with obturator artery which is noted in 2.6% of specimens in **present study** (2007)

e. Superior vesical artery:

Braithwaite (1952)[25] and **Anson** (1941)[23] stated that superior vesical artery arises from the pelvic part of the umbilical artery which remains patent and the same finding is noted in the **present study** (2007*).*

Parsons and Keith (1897)[14] reported that the superior vesical artery arose from the hypogastric trunk (the common trunk for vesical and middle rectal arteries), the anterior division; and in common with the middle rectal artery from the hypogastric trunk.

In the **present study**, *in none of the cases it originates from hypogastric trunk or anterior division or from internal iliac artery as mentioned by Parson.*

Dubreuil- Chambardel (1925)[21] found a single superior vesical artery in 9%; two arteries in 74%; three arteries in 9%; four in 6%; and five arteries in 2% of the cases he studied.

The number of superior vesical arteries varies from 2 to 3 as per **B. J. Anson** et al (1941)[23]; 1 to 4 according to **Braithwaite** (1952)[25] and 1 to 5 according to **Bergman** (1988)[8].

*The number of superior vesical arteries varies from 1 to 3 in **present study**(Chart no 2) similar to that of Anson and also found in majority of cases of other authors table no. 27.*

f. Inferior vesical artery:

Parsons and Keith (1897)[14] reported on 58 observations that the inferior vesical artery originates in 22.4% as a separate vessel from the anterior division.

George A. Piersol (1930)[10] and **Susan Standring (**2005)[39] quoted that inferior vesical artery arises from the anterior division of internal iliac artery.

In the present study (2007) *inferior vesical artery is a branch of anterior division in 75% of specimens as stated by the above said authors though more than the finding of Parson.*

Parsons and Keith (1897)[14] reported that in 8.7% inferior vesical artery arises as a separate vessel or in common with other branches from the internal iliac artery.

Braithwaite (1952)[25] stated that in 25.7% of cases, it arose from the internal iliac artery. **Piersol[10]** and **Anson**[23] have also mentioned about similar origin.

In the present study (2007*) inferior vesical artery is a branch from internal iliac artery either separately or in common with other branches in 25% as stated by Anson, Piersol and Braithwaite though more than that of Parson.*

Origin of inferior vesical artery in common with internal pudendal was observed by **Anson[23]** and by **Braithwaite**[24] in 51.4% *while similar finding is noted in only 15.6% in the* **present study.**

Other origins as observed by authors namely from hypogastric trunk by Parson, inferior gluteal artery and middle rectal artery by Anson, from superior gluteal artery and common trunk for inferior gluteal artery and internal pudendal artery are not found in any specimen in the present study.

g. Middle rectal artery:

Parsons and Keith (1897)[14] found that middle rectal artery arose in 33.3% from the anterior division of internal iliac artery.

George A. Piersol (1930)[10] and **Gray's Anatomy (**2005)[39] stated that middle rectal artery originates from anterior division.

In the present study (2007) *middle rectal artery takes origin from anterior division in 60.5%, similar to the findings of other authors though it is more than Parson's finding.*

Parsons and Keith (1897)[14] found that in 22.2% it came from the internal iliac artery while similar finding is noted in16.8% by **DiDio** (1986)[33] and in 7.9% in the **present study** (2007) which is less than the findings of these authors.

Origin of middle rectal artery in common with internal pudendal was noted by **Parson** [14] in 13.3%; **Anson** (1941)[23] in 40.9%; **DiDio**[33] in 56.7% and also mentioned by **Bergman**.[8]

In the present study, *origin from internal pudendal artery is observed in 47.4% which is comparable to the findings of Anson and DiDio, though more than that of Parson.*

Origin of middle rectal artery from inferior gluteal artery was noted by **Parson**[14] in 4.4%, **Anson**[23] in 22.7%; **DiDio**[33] in 26.7%; also mentioned by Bergman.

In the present study, *similar origin is observed in 10.6% which is less than that of Anson and DioDio and more than that of Parson (Table no. 28).*

*Two middle rectal arteries are found in only 2.6% in the **present study** while it was noted in 21% in **Dubrueil's** study (1925)[21].*

*In the **present study** middle rectal artery is absent in 5.3% of specimens which is also mentioned by **Anson**[23] and **Bergman**[8]; but less than that found by **Di Dio**[33] (43.3%).*

h. Uterine artery:

Parsons and Keith (1897)[14] found that in 16.9% uterine artery was a separate branch of the anterior division.

George A. Piersol (1930)[10] stated that uterine artery usually arises from the hypogastric, but sometimes from the proximal part of the superior vesical artery or from the anterior division of the hypogastric artery.

W.H. Roberts & Gene L. Krishinger (1967)[29] studied on the origin of uterine artery found that it originated from anterior division in 61.4%

Susan Standring (2005)[39] stated that uterine artery arises from anterior division

In the present study (2007) out of the 6 specimens studied *uterine artery arises from anterior division in three of them which is mentioned by other authors.*

B. J. Anson et al (1941)[23] in their study on the origin of uterine artery in 7 specimens found that in 2 specimens uterine artery arises by a common stem with the umbilical.

Roberts et al[29] found that uterine artery originates from umbilical artery in 43.2%.

In the **present study** *similar origin from umbilical artery is noted in 3 out of 6 specimens studied.*

i. Vaginal artery:

Dubreuil- Chambardel (1925)[21] found that vaginal artery may arise from a common trunk with the uterine in 16%.

George A. Piersol (1930)[10] said that the vaginal artery is a branch of anterior trunk and also arises from the hypogastric or from the inferior vesical artery or from middle rectal artery.

Grant (1957)[7] said that vaginal artery arises directly from anterior division, or in common with uterine artery.

Susan Standring (2005)[39] stated that vaginal artery is a branch from anterior trunk.

*In the **present study** (2007) vaginal artery arises from umbilical artery in four out of six specimens which was not observed by any of these authors; from anterior division in 1*

specimen as stated by Susan, Piersol and Grant. It arises in common with uterine artery in a single specimen, also mentioned by Dubrueil and Grant.

j. Superior gluteal artery:

Parsons and Keith (1897)[14] said that superior gluteal artery must always be the terminal branch of the posterior division.

Piersol (1930)[10] said that posterior division continues as superior gluteal artery.

Susan Standring (2005)[39] stated that superior gluteal artery is the largest branch and the continuation of posterior trunk.

In the present study *(2007) superior gluteal artery is found to be the terminal branch of posterior division in 78.9% as stated by Parson, Susan and Piersol.*

Morris (1953)[11]quoted that superior gluteal artery arises from posterior and lateral part of hypogastric artery associated in origin with iliolumbar artery, lateral sacral artery and sometimes with inferior gluteal artery; both inferior gluteal and internal pudendal artery.

In the present study *its direct origin from internal iliac artery as stated by Morris is noted in 21.1%. It is associated with inferior gluteal artery in 15.8%; with lateral sacral artery and iliolumbar artery in 63.2% which also correlate with the findings of Morris. However no origin in common with both inferior gluteal and internal pudendal artery are noted.*

k. Iliolumbar artery:

Parsons and Keith (1897)[14] said that in 29.8% iliolumbar artery arose directly from the posterior division.

Susan Standring (2005)[39] stated that iliolumbar artery is a branch from posterior trunk while **Piersol**[10] also noted it frequently.

In present study (2007) *iliolumbar artery starts from posterior division in 52.6% which is more than Parson's study.*

Parsons and Keith (1897)[14] found that in 61.4% iliolumbar artery arose entirely from the internal iliac. *Similar origin is noted in 47.4% in* ***the present study***.

Piersol (1930)[10] said that iliolumbar artery starts from the main stem of internal iliac artery before division *while in the* ***present study*** *it is found in 21.1%.*

Morris *(1953)[11] noted origin of iliolumbar artery in common with superior gluteal artery while similar origin is noted in 13.2% of the* ***present study***.

l. Lateral sacral artery:

Skandalaki (2004)[4] said that lateral sacral artery arises as 1 to 3 vessels.

In the ***present study*** *the number of lateral sacral artery varies from one to three as stated by Skandalaki (Table no.29).*

Poynter (1922)[20] found a single artery in 55% and 2 in 45% of specimens.

Morris (1953)[11] stated that it arises as a single branch dividing into two or as 2 distinct vessels.

In the **present study** *it arise as a single branch as mentioned by Morris in 63.2%.*

Piersol (1930)[10], **Ronald A. Bergman** (1988)[8] and **Susan Standring** (2005)[39] stated that lateral sacral artery is usually 2 in number.

In the **present study** 2 lateral sacral arteries are found in 26.3%.

Piersol (1930)[10], **Grant** (1957)[7]**, Hollinshead** (1961)[12] and **Gray's Anatomy** (2005)[39] stated that lateral sacral artery is from posterior division.

In the present study lateral sacral artery arise from posterior division in 44.7% as mentioned by these authors.

Poynter (1922)[20] stated that it originates from internal iliac artery in 22% of specimens.

In the present study a similar origin is noted in 42.2% which is higher than Poynter's study. Other origins namely from anterior division in common with inferior gluteal artery (5.3%) and from both main stem of internal iliac artery and posterior division (7.9%) observed in the present study were not mentioned by these authors.

m. Branching pattern:

Lipshultz (1918)[19] classified the branching pattern of internal iliac artery based on the three large branches namely inferior gluteal artery ,internal pudendal artery , and superior gluteal artery (table no.30).

On comparison, the first type is the most common in both though of more frequency in the present study. The order of frequency is reversed in the present study regarding second and third types. The fourth type mentioned by the author is not met with in the present study.

Adachi(1928)[22] classified the branching pattern based on the three large branches namely inferior gluteal artery ,internal pudendal artery , and superior gluteal artery based on his study on 118 pelvic halves.

Braithwaite (1952)[24] dissected 169 pelvic halves**, Fischer (1952)**[27] dissected 50 pelvic halves and **Roberts and Krishinger (1967)**[29] dissected 167 specimens and summarized their findings in accordance with Adachi's classification. The present study is compared with their findings as in table number 31 (Chart no 3).

Type I where the superior gluteal artery arises separately from the internal iliac artery, and the inferior gluteal and internal pudendal vessels are given off by a common trunk was found in 51.2% of cases by Adachi while in 63.2% in the present study which is comparable to that of Adachi. The latter divides within the pelvis (Type Ia), in 60.5% in present study which is more than the studies of above said authors, whereas the bifurcation occurs below the pelvic floor (Type Ib) in 2.6% which is less than the values of other authors.

Type II where the superior and inferior gluteal arteries arise by a common trunk and the internal pudendal vessel separately is found in 15.8% in the present study. In all the specimens the trunk divides proximal to the pelvic floor (Type IIa) which is more than that of the other authors. No type Type IIb was found where the division occurs outside the pelvis.

Type III: The three branches arise separately from the internal iliac artery in 21.1% of present study which is comparable to that of Adachi and Braithwaite while slightly higher than that of other authors.

On comparison, it is evident that the present findings are in accord with that of the previous studies in that Type Ia is most common. No specimen of Type IIb, IV or V is met with in the present study. The authors other than Adachi also, just like the present study never came across the type V where a common trunk divides into internal pudendal artery and superior gluteal artery.

Types I, II, III are in the order of I>III>II in the present study which coincides with that of Braithwaite, while the order is I>II>III by Adachi, Fischer, Roberts which is against the present findings.

Ashley and Anson (1941)[23] classified the branching pattern based on inferior gluteal artery, internal pudendal artery, superior gluteal artery and umbilical artery and subtypes based on obturator artery (Chart no 4).

Latha V. Prabhu et al (2001)[9] studied on the principal branches of internal iliac artery in 20 cadavers based on Anson and Ashley's classification. In the **present study** only 3 types out of nine types described by Anson are found (table no.32).

Type III –The superior gluteal artery is the only one arising separately, the other branches emerge from a common trunk is found in 21.1% in the present study which is comparable to Latha V. Pillai et al study but more than Anson's finding.

Type IV – The two common stems give off two branches each, the gluteals from one and the others from the next is found in 15.8% in present study which coincides with Anson's finding but more than that of Latha V. Pillai et al study.

Type V – The inferior gluteal and internal pudendal arise from a common stem, the umbilical and superior gluteal arising as separate branches is found in 63.2% in the present study which correlates with that of both the authors.

In the present study Type V is found to be the most common, this is coincident with that of other studies. In both present and Latha V. Prabhu *et al studies, types III, IV and V are made out while other types are never met with. The order of frequency is V> III> IV in present and Latha V. Prabhu studies while it is V> IV >III in Anson's study.*

***Gasparri and Brizzi** (1964)*[28] adopted a classification based on only 3 types as type IV (where inferior gluteal artery, internal pudendal artery, superior gluteal artery arise by a common stem) of Adachi's classification was not distinguished from type III (where inferior

gluteal artery, internal pudendal artery, superior gluteal artery arise separately) since the two are very similar (table no.33).

Type I is the most common in the present study which coincides with that of Gasparri studies; Type II is found in 15.8% which is less than that of author. Type III is closer to the frequency of author.

*The **Clinical importance** underlying the branching pattern of internal iliac artery is that* any deviation in the normal arterial pattern can lead to life threatening hemorrhage during surgery in the vicinity. In internal iliac artery ligation done for various indications, a most important indication being uterine hemorrhage, a thorough understanding of the pelvic vasculature and also of the possible individual variations is a must for pelvic surgeons. In this procedure anterior division should be preferably ligated distal to the posterior parietal branch so that flow can still occur distal to the point of ligation only as redistribution of flow in the middle rectal arteries while the flow in the iliolumbar artery and lateral sacral artery continues to be normal[36]. Any number of radiological procedures involving internal iliac artery requires a detailed knowledge of these variations, in order to perform either diagnostic or therapeutic procedure.[26]

5. Obturator artery:

a. Origin of obturator artery:

In the **present study** origin of obturator artery from internal iliac artery and its branches is 57.8% which correlates with that of **Gray**[5] and **Morris**[11] while it is less than that of **Poynter**[20]**, Piersol**[10]**, Pick**[44]**, Braithwaite**[24]**, Roberts**[29] **and Bergman**[8]**.**

In the present study obturator artery originates from anterior division in 23.7% which is less than that of Poynter, Braithwaite and Roberts. It is found to take origin from the common

trunk for inferior gluteal artery and internal pudendal artery in 13 % which is similar to that of Poynter, Braithwaite. It takes origin from inferior gluteal and internal pudendal artery each 2.6% which are less than the study of Poynter, Braithwaite. In the present study obturator artery originates from superior gluteal in 5.3% which is less than Poynter, Braithwaite. It originates from posterior division in 5.3% which is less than Roberts while it is more than Braithwaite (table 34).

b. **Abnormal Obturator artery:**

In the **present study** origin from external iliac artery and its branch is 36.9% which is comparable with that of **Gray**[5] and **Morris**[11] while it is less than that of **Poynter**[20]**, Piersol**[10]**, Pick**[44]**, Braithwaite**[24]**, Roberts**[29] **and Bergman**[8] (Chart no 5).

Dubreuil Chambardel (1925)[21] found obturator artery arising from inferior epigastric artery in 29.5% of cases, while **J.C.B Grant** (1957)[7] in 25.4% and **Skandalakis** (2004)[4] in 33% of the specimens, while in the **present study** (2007) it is found in 31.6% of specimens which correlates with the values of these authors.

c. Bilateral similarity:

Dubrueil and Chambardel(1925)[21] by summarizing different studies, found bilateral abnormal obturator artery to be 23.7% whereas in the **present study** it is found in 21% (4 out of 19 pelves)which is closer to the study of Dubrueil (table no.35). This is against the statement of **Gray** (1901)[5] who said that the origin of obturator artery from inferior epigastric artery is not commonly found on both sides of the same body.

d. Origin from 2 roots:

Braithwaite (1952)[24] found the origin of obturator artery by 2 roots in 6.5% while **Grant** (1957) found in 4.6% of cases.

In the present study (2007), *the origin from 2 roots is observed in two specimens (5.3%) which is almost similar to the frequency observed by Grant and Braithwaite.*

Sundarapandian S. et al (2004)[50] identified an abnormal obturator artery in routine cadaveric dissection. It was formed by a branch of inferior epigastric artery (pubic branch) joining a branch of superior gluteal artery (obturator branch). The place of formation is at the upper part of obturator foramen.

*In the **present study** in one specimen the 2 roots are from inferior epigastric and superior gluteal artery similar to that observed by Sundarapandian et al. while the other specimen had 1 root from inferior epigastric artery and the other from posterior division.*

e. Relation to femoral ring:

Jastschinski (1891)[13] quoted that the abnormal obturator artery is related to the lateral border of the femoral ring of the 60% of the cases while **Grant**[7] found a similar finding in 70%.

In the **present study** in 87.5% the abnormal obturator artery has its course lateral to the femoral ring which is more than that of the authors.

In the present study, in 12.5% the artery is related medial to the femoral ring and hence along the margin of lacunar ligament which is less than that of **Jastschinski** (17.9%)[13] and **Grant**[7] who noted this in 30% of specimens.

Jastschinski[13] stated that in 22.5% abnormal obturator artery is related across the femoral ring. *Not a single case with that relation is found in the present study (Chart no 6).*

*The **surgical significance** underlying obturator artery is that the* artery runs a greater risk of being wounded during the operation for strangulated femoral hernia. When it arises from the external iliac in rarer cases, which seem to be principally those in which the common trunk of the obturator and epigastric is longer than usual, the obturator takes a more circuitous course, passing along the upper margin of the femoral ring, and then along its inner or pubic margin. It must be evident that when a femoral hernia descends, the relative position of the artery to the neck of the sac, in these two cases, is very different, and, in a practical point of view, involves very important considerations[44].If both normal and abnormal obturator arteries are present, then the arrangement is called as **"circle of death**" because of profuse bleeding that can occur when either vessel is severed[4].

IN FETUSES:

George A. Piersol (1930)[10] stated that in the arrangement of branches of foetal hypogastric artery four types are recognized leaving out the consideration for the smaller branches.

The ***first type*** has two large trunks arising from the hypogastric, the posterior one being the gluteal and the anterior, a trunk which divides into the internal pudendal and inferior gluteal. *Similar pattern is observed in 66.7% in the **present study**.*

The ***second type*** is that in which the three vessels arise independently from the hypogastric. *In the **present study** this pattern is noted in 25% of fetal specimens*.

The ***third type*** is that in which the superior gluteal and inferior gluteal arteries arise by a common trunk from the hypogastric, the internal pudendal remaining distinct. *In the **present study** this pattern is found in 8.3%.*

The ***fourth type*** is where all three large vessels arise from a common stem, in which there will be no apparent separation into an anterior and a posterior division. *In the **present study** not a single specimen revealed this pattern of branching.*

Pelvic Angiogram:

Adult pelvic angiograms were studied to understand the course of the branches in relation to the bony landmarks. This is clinically significant in performing various interventional procedures and in diagnosis of pelvic pathology.

Foetal pelvic angiograms reveal that internal iliac artery is the main continuation of common iliac artery in contrast to that in adults and also signifies its extension as umbilical artery. The branches of internal iliac artery are also noted.

CONCLUSION

Internal iliac artery, the vessel of surgical and radiological significance, has been studied in detail by dissection and radiological methods. The length of the artery, its extent, its relation with the adjacent important structures, its branches and branching pattern and obturator artery in detail have been observed and correlated with the findings of already existing studies. The following conclusions are derived from these parameters:

- The mean length of internal iliac artery is 3.7cm. The minimum length is 2.3cm and the maximum length is 7.1cm.

- Internal iliac artery originates in most of the cases at the level of lumbosacral articulation.

- In majority of specimens, internal iliac artery bifurcates at the level of upper border of greater sciatic notch.

- Internal iliac artery is related to ureter anteriorly and internal iliac vein posteriorly. Common iliac vein and external iliac vein are posterolateral to the artery.

- The most common mode of termination of internal iliac artery is by dividing into anterior and posterior divisions.

- In most of the specimens one or two branches arise from the main stem of internal iliac artery even before its bifurcation. However, in a significant proportion it is found to give rise to larger terminal branches without dividing into two trunks.

- The *anterior division* gives rise to inferior gluteal artery, internal pudendal artery, obturator artery, superior vesical artery, inferior vesical artery, middle rectal artery, and uterine and vaginal artery in females. However inferior gluteal artery, obturator artery and middle rectal artery are noted to arise from posterior division in a few instances.

- The *posterior division* gives origin to lateral sacral artery, iliolumbar artery and superior gluteal artery, of which lateral sacral artery is noted to originate from anterior division in a few specimens.

- Bilateral and unilateral abnormal obturator artery is found to arise from external iliac artery or its branch namely inferior epigastric artery in significant proportion of cases.

- Origin of abnormal obturator artery by two roots, from both internal iliac artery and external iliac artery is also noted.

- Abnormal obturator artery is related in most of the cases to the lateral border of femoral ring.

- The highest proportion of cases display the branching patterns namely Type I of Adachi's classification and Type V of Anson's classification.

- Among the twelve fetal specimens studied internal iliac artery is in line with the common iliac artery in contrast to that of adults where external iliac artery is in line with common iliac artery.

- The branches and branching pattern of foetal internal iliac artery are studied and inferior gluteal artery and obturator artery noted to originate from posterior trunk in a few cases. In a significant proportion there was no clear cut division into anterior and posterior trunks.

- Under radiological study, the anatomical knowledge is further extended to identify and precisely locate the various branches of internal iliac artery, which are of importance in the angiographic procedures.

Based on this study, I hereby conclude that the "arterial tree" of internal iliac artery is composed of complex variations in the length, extent and its branches.

Starting from surgery for femoral hernia to the latest procedures of interventional radiography, require a thorough knowledge of variations in internal iliac artery and its branches. Hence I hope that this study would be of great use to surgeons and radiologists.

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Table -1

Branches of internal iliac artery according to Frazer (1937):

ANTERIOR DIVISION		POSTERIOR DIVISION
VISCERAL	**PARIETAL**	**PARIETAL**
Umbilical artery (which gives off superior vesical artery)	Obturator artery	Iliolumbar artery
Inferior vesical artery	Internal Pudendal artery	Lateral sacral artery
Middle rectal artery	Inferior gluteal artery	Superior gluteal artery

Table-2

Observations of Braithwaite (1952):

	FEMALE		MALE		TOTAL	
Types	**Number**	**Percentage %**	**Number**	**Percentage %**	**Number**	**Percentage %**
Ia	25	40.9	57	52.7	82	48.5
Ib	5	8.2	12	11.1	17	10
IIa	11	18	9	8.3	20	11.8
IIb	4	6.5	2	1.8	6	3.5
III	13	21.3	25	23.1	38	22.5
IVa	2	3.2	2	1.8	4	2.4
IVb	1	1.6	1	0.9	2	1.2
V	-	-	-	-	-	-
TOTAL	61	99.7	108	99.7	169	99.9

Table-3

Number of superior vesical artery –Findings of Braithwaite:

Number of superior vesical arteries	**Number of sides**	**Percentage %**
1	15	21.4
2	28	40
3	24	34.3
4	3	4.3
Total	70	100

Table-4

Observations of Fischer (1959) according to Adachi's classification:

Types	Ia	Ib	IIa	IIb	III	IVa	IVb	Total
Number	23	2	6	7	8	1	3	50
Percentage	46	4	12	14	16	2	6	100

Table-5

Observations of W.H. Roberts et al (1967) according to Adachi's classification:

Types	I_a	I_b	II_a	II_b	III	IV_a	IV_b	V	VI	Total
Number	75	10	42	3	24	9	3	0	1	167
Percentage	45	6	25	1.8	14.4	5.4	1.8	0	0.6	100

Table-6

Origin of the Middle Rectal Artery- Findings of Ronald A. Bergman (1988):

Origin	Percentage
1. Arises directly from the internal iliac artery	40%
2. From a common trunk with:	
a) 2. Prostatic/inferior vesical artery	12%
b) 3. Inferior vesical artery	10%
c) 4. Internal pudendal	20%
d) 5. From the inferior sciatic/internal pudendal trunk	18%

Table-7

Observations of Latha V. Prabhu et al (2001) according to Anson's classification:

Type	I	II	III	IV	V	VI	VII	VIII	IX	Unusual type	Total
Number	0	0	11	2	26	0	0	0	0	1	40
Percentage	0	0	27.5	5	65	0	0	0	0	2.5	100

Table-8

Frequency of Origin of the Obturator from Inferior Epigastric Artery summarized by Poynter (1922):

Name	Year	Number of Observations	Percentage
Cloquet	1817	500	30.4
Breschet	1819	63	19
Hesselbach	1819	64	43.3
Quain	1844	360	31.4
SchlÃbig	1844	112	21
Isaacs	1855	706	18.3
Wyeth	1878	52	34
Hoffmann	1878	400	32.5
Hartmann	1881	180	19
Krusche	1885	80	20
Pfitzner	1889	226	37.6
Jastschenski	1891	404	24
Dwight	1895	500	25
Levi	1902	200	25.2
Poynter	1922	400	26.2
Dubreuil-Chambardel	1925	440	29.5
Total		4484	25.1

Total No. Observations = 4,484, Frequency = 25.1%

Table-9

Sources of obturator artery summarized by Dubrueil-Chambardel (1925):

Author(s)	Total Number	Obturator from Internal Iliac		Obturator from External Iliac	
		Number	Percentage	Number	Percentage
Cloquet (Paris)	500	348	69.6	152	30.4
Hoffmann (Bale)	400	270	67.5	130	32.5
Quain (London)	361	246	68.6	115	31.4
Pfitzner (Strasbourg)	226	141	62.4	85	37
Hartmann (Berlin)	180	146	81	34	19
SchlÃ¶big (Leipzig)	112	78	69.6	34	21
Krusche (Dorpat)	80	63	78.8	17	20
Hesselbach (Wurzburg)	64	37	57.7	27	43.3
Breschet (Paris)	63	51	81	12	19
Wyeth/Warwell (London)	52	34	66	18	34
Dwight (America)	500	371	74.2	129	25.8
Jastschinski (Varsovic)	1034	723	70	311	30
Levi (Florence)	110	82	74.8	28	25.2
Dubreuil-Chambardel (Paris)	440	310	70.5	130	29.5
Total	**4122**	**2900**	**70.84%**	**1222**	**28.4%**

Table-10

Abnormal obturator artery- summarized by Dubrueil(1925):

Author	Total number of pelves	Bilateral	Unilateral
Cloquet	250	62	28
Quain	159	25	38
Hesselbach	32		27
Pfitzner	105		71
Dubreuil-Chambardel	130	41	49
Uni-/Bilateral Side Totals	539	128 **(23.7%)**	115

Table-11

Origins of obturator artery –Findings of Braithwaite (1952):

Origin	Number	Percentage
A. From Internal Iliac Artery:		
Direct branch from anterior division	70	41.4
Inferior gluteal-internal pudendal trunk	17	10
Inferior gluteal artery	8	4.7
Internal pudendal artery	6	3.8
Superior gluteal artery	17	10
Iliolumbar artery	5	3.5
B. From External Iliac Artery		
Direct branch	2	1.1
Inferior epigastric artery	33	19.5
C. From Internal and External Iliac Arteries:		
By double origin	11	6.5
Totals:	169	99.5

Table-12
Length of internal iliac artery:

Specimen	1R	3R	3L	4R	4L	6L	7R	7L	8R	8L	9L	10R	10L	11R	11L
Length-cms	7	4.7	4.1	5	5.2	3.3	3.7	3.6	3.2	4.2	2.5	2.3	7.1	3.4	3.3

Specimen	12R	12L	13R	13L	14R	14L	15R	16R	16L	17R	17L	18R	18L	19R	19L
Length-cms	3.5	3.2	2.6	2.7	5.1	2.8	5.3	3	3.2	2.4	2.3	3.1	3.3	2.4	2.8

Table -13

Origin of internal iliac artery in relation to lumbosacral joint:

Specimen	**Level**	**Specimen**	**Level**
1R	Above	10L	At
1L	Above	11R	At
2R	Above	11L	At
2L	Above	12R	At
3R	At	12L	At
3L	At	13R	At
4R	Above	13L	At
4L	Above	14R	At
5R	At	14L	At
5L	At	15R	At
6R	At	15L	Above
6L	Above	16R	Above
7R	At	16L	At
7L	At	17R	At
8R	At	17L	At
8L	At	18R	Above
9R	At	18L	At
9L	At	19R	At
10R	At	19L	At

At-at the level of lumbosacral articulation
Above-above the level of lumbosacral articulation
L - Left; R - Right

Table-14

Branches from the main trunk of internal iliac artery before its termination into anterior and posterior divisions:

Branch	Number	Percentage
a. Iliolumbar artery	5	16.7
b. Lateral sacral artery	6	20
c. Iliolumbar artery and lateral sacral artery as separate branches	1	3.3
d. Iliolumbar artery and lateral sacral artery as a common trunk	2	6.6
e. Iliolumbar artery as separate branch and lateral sacral artery and middle rectal artery as common trunk	1	3.3
f. Common trunk for iliolumbar artery and middle rectal artery	1	3.3
g. Lateral sacral artery and middle rectal artery as separate branches	1	3.3
h. No branch before division	*13*	*43.3*
Total	*30*	*99.8*

Table-15

Origin of inferior gluteal artery:

Origin	*Number*	*Percentage*
A. From anterior division:	***24***	***63.2***
a. In common with internal pudendal artery	*21*	*55.3*
b. In common with internal pudendal artery& middle rectal artery	*1*	*2.6*
c. In common with internal pudendal artery and lateral sacral artery	*1*	*2.6*
d. In common with internal pudendal artery and obturator artery	*1*	*2.6*
B. From posterior division:	***6***	***15.8***
a. In common with superior gluteal artery	*3*	*7.9*
b. In common with superior gluteal artery & middle rectal artery	*2*	*5.3*
c. . In common with superior gluteal artery & lateral sacral artery	*1*	2.6
C. From internal iliac artery	***8***	***21.1***
a. Direct branch	*5*	*13.2*
b. In common with middle rectal artery	*2*	*5.3*
c. In common with iliolumbar artery	*1*	*2.6*

Table-16

Origin of internal pudendal artery:

Origin	**Number**	**Percentage**
***From anterior division*:**	**30**	**78.9**
a. Direct branch	3	7.9
b. in common with inferior gluteal artery	24	63.1
c. in common with inferior vesical artery	3	7.9
***From internal iliac artery* :**	**8**	**21.1**
a. Direct branch	3	7.9
b. in common with middle rectal artery	3	7.9
c. in common with obturator artery	1	2.6
d. in common with inferior vesical artery	1	2.6

Table-17

Number of superior vesical artery:

Number of superior vesical artery	*Number of pelvic halves*	*Percentage*
1	*20*	*52.6*
2	*14*	*36.8*
3	*4*	*10.5*

Table-18

Origin of inferior vesical artery:

Origin	*Number*	*Percentage*
From anterior division	***24***	***75***
a. Direct branch	*5*	*15.6*
b. Umbilical artery	*15*	*46.8*
c. in common with internal pudendal artery	*4*	*12.5*
From internal iliac artery	***8***	***25***
a. Direct branch	*2*	*6.3*
b. Umbilical artery	*5*	*15.6*
c. in common with internal pudendal artery	*1*	*3.1*

Table-19

Origin of middle rectal artery:

Origin	***Number***	***Percentage***
From main stem before division	***3***	***7.9***
From anterior division	***23***	***60.5***
a. In common with internal pudendal artery	13	*34.2*
b. In common with common trunk for internal pudendal artery and inferior gluteal artery	8	*21.1*
c. In common with inferior gluteal artery	*2*	*5.3*
From posterior division	***2***	***5.3***
From internal iliac artery	***8***	***21.1***
a. In common with internal pudendal artery	*5*	*13.2*
b. In common with inferior gluteal artery	*2*	*5.3*
c. In common with obturator artery	*1*	*2.6*
Absent	***2***	***5.3***

Table-20

Origin of vaginal artery:

Origin	**Number of specimens**
From umbilical artery	4
From uterine artery	1
From anterior division	1
Total	6

Table-21

Origin of superior gluteal artery:

Origin	Number	Percentage
***Posterior division**:*	***30***	***78.9***
A. as only terminal branch	*24*	*63.2*
B. in common with inferior gluteal artery	*6*	*15.8*
***Internal iliac artery** :*	***8***	***21.1***
A. direct branch	*1*	*2.6*
B. lateral sacral artery	*1*	*2.6*
C. Iliolumbar artery and lateral sacral artery	*4*	*10.5*
D. Iliolumbar, Lateral sacral artery and obturator artery	*1*	2.6
E. Lateral sacral artery and obturator artery	*1*	*2.6*

Table-22

Origin of iliolumbar artery:

Origin	Number	Percentage
Among 30 specimens where internal iliac artery divides into 2 divisions		
A. From posterior division:	***20***	***52.6***
B. From main stem before its division	***10***	***26.3***
Among 8 specimens where internal iliac artery does not divide into 2 divisions		
C. From internal iliac artery	***8***	***21.1***
a. In common with superior gluteal artery and lateral sacral artery	*4*	*10.6*
b. In common with superior gluteal artery and obturator artery	1	2.6
c. In common with inferior gluteal artery	*1*	*2.6*
d. Direct branch	*2*	*2.6*

Table-23

Number of lateral sacral arteries:

Number of lateral sacral arteries	*Number of pelvic halves*	*Percentage*
1	*23*	*60.5*
2	*11*	*28.9*
3	*4*	*10.5*

Table-24
Origin of lateral sacral artery:

Origin	**Number**	**Percentage**
Among 30 specimens where internal iliac artery divides into 2 divisions		
A. From posterior division	**18**	**47.3**
a. direct branch	17	44.7
b. in common with inferior gluteal artery	1	2.6
B. From both posterior division(2 vessels) **and main stem**(1 vessel)	***3***	***7.9***
C. From main stem before its division	***8***	***21.1***
D. From anterior division in common with inferior gluteal artery	***1***	***2.6***
Among 8 specimens where internal iliac artery does not divide into 2 divisions		
E. From internal iliac artery	***8***	***21.1***
a. In common with superior gluteal artery	*1*	*2.6*
b. In common with superior gluteal artery and iliolumbar artery	*4*	*10.6*
c. In common with superior gluteal artery and obturator artery	1	*2.6*
d. In common with superior gluteal artery, iliolumbar artery and obturator artery	1	2.6
e. Direct branch	1	*2.6*

Table-25

Origin of obturator artery:

ORIGIN	MALE (32)		FEMALE (6)		TOTAL (38)	
	No	**%**	**No**	**%**	**No**	**%**
FROM IIA						
From Anterior division	9	28.1	-	-	9	23.7
From Common trunk for IG & IP	5	15.6	-	-	5	13.2
From Inferior gluteal artery	1	3.1	-	-	1	2.6
From Internal pudendal artery	1	3.1	-	-	1	2.6
From Superior gluteal artery	2	6.3			2	5.3
From Posterior division	2	6.3	-	-	2	5.3
From Umbilical artery	2	6.3	-	-	2	5.3
TOTAL	22	68.6	-	-	**22**	**57.9**
FROM EIA						
From main stem	2	6.3	-	-	2	5.3
From Inferior epigastric artery	8	25	4	66.7	12	31.6
TOTAL	10	31.2	4	66.7	**14**	**36.8**
FROM 2 ROOTS	-	-	2	33.3	**2**	**5.3**

Table-26

Origin of inferior gluteal artery:

Origin	Parson &Keith(1897) %	Present study(2007) %
Anterior division	75	63.2
Posterior division	21.4	15.8
Internal iliac artery	1.8	21.1

Table-27

Number of superior vesical artery:

Number of superior vesical arteries	Dubruiel (1925) %	Braithwaite (1952) %	Present study (2007) %
1	9	21.4	*52.6*
2	74	40	*36.8*
3	9	34.3	*10.6*
4	6	4.3	-
5	2	-	-

Table-28

Origin of middle rectal artery:

Origin	Parson Study %	DiDio study %	Present study %
Internal pudendal artery	13.3	40	47.4
Inferior gluteal artery	4.4	26.7	15.8
Internal iliac artery	22.2	16.8	7.8

Table-29

Number of lateral sacral artery:

Number of lateral sacral artery	*Poynter's study %*	*Present study %*
1	*55*	*63.2*
2	*45*	*26.3*
3	-	*10.5*

Table-30

Comparison with Lipshultz's study:

Branching Pattern	**Lipshultz**	**Present study**
a. Superior gluteal artery arises separately & inferior gluteal artery and internal pudendal artery given off by common trunk	51%	63.2%
b. Superior gluteal artery and inferior gluteal artery arise by a common trunk and internal pudendal artery given off separately	24%	15.8%
c. Superior gluteal artery, inferior gluteal artery and Internal pudendal artery are given off separately	17%	21.1%
d. Superior gluteal artery, inferior gluteal artery and internal pudendal artery arise by a common trunk	7%	nil

Table-31

Comparison with studies based on Adachi's classification:

Study	**Ia**	**Ib**	**IIa**	**IIb**	**III**	**IVa**	**IVb**	**V**
Adachi (1928) %	51.2		23.1		18.2	4.1		0.8
Braithwaite (1952) %	48.5	10	11.8	3.5	22.5	2.4	1.2	-
Fischer(1952)%	46	4	12	14	16	2	6	-
Roberts et al (1967)%	45	6	25	1.8	14.4	5.4	1.8	-
Present study (2007)%	60.6	2.6	15.8	-	21.1		-	-

Table-32

Comparison with Anson's classification:

Types	Ashley and Anson study		Latha V. Prabhu et al study		Present study	
	No	%	No	%	No	%
I	1	0.4	0	0	-	-
II	6	2.3	0	0	-	-
III	25	9.6	11	27.5	8	21.1
IV	45	17.3	2	5	6	15.8
V	151	58.1	26	65	24	63.2
VI	20	7.7	0	0	-	-
VII	10	3.8	0	0	-	-
VIII	1	0.4	0	0	-	-
IX	1	0.4	0	0	-	-
Unusual type	-	-	1	2.5	-	-
Totals	260	100	40	100	38	100

Table-33

Comparison with Gasparri et al study:

Study	Type I	Type II	Type III
Gasparri & Brizzi (1964) %	50	31.4	18.6
Present study(2007) %	63.2	15.8	21.1

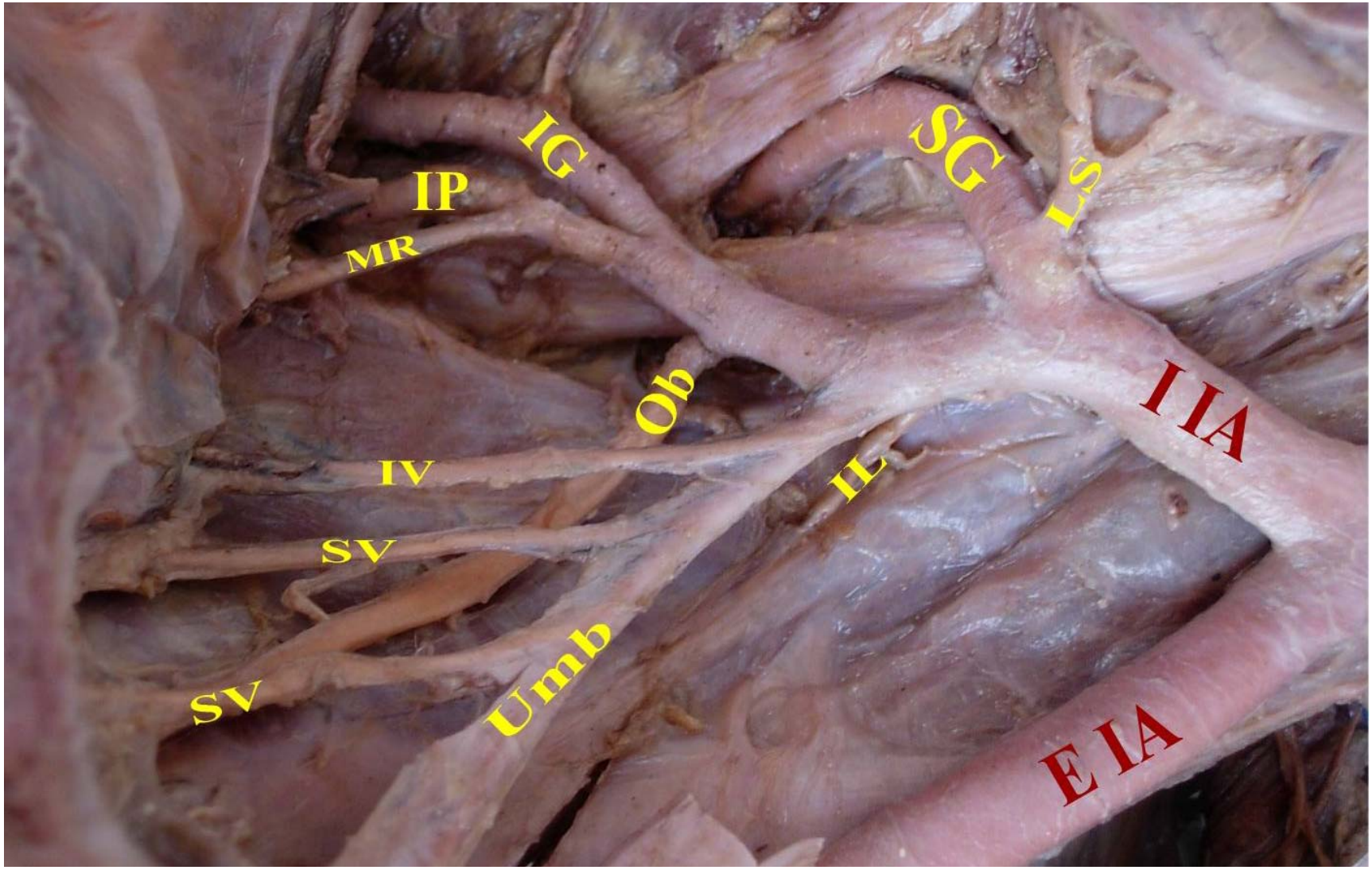
Table-34

Comparison of origins of obturator artery:

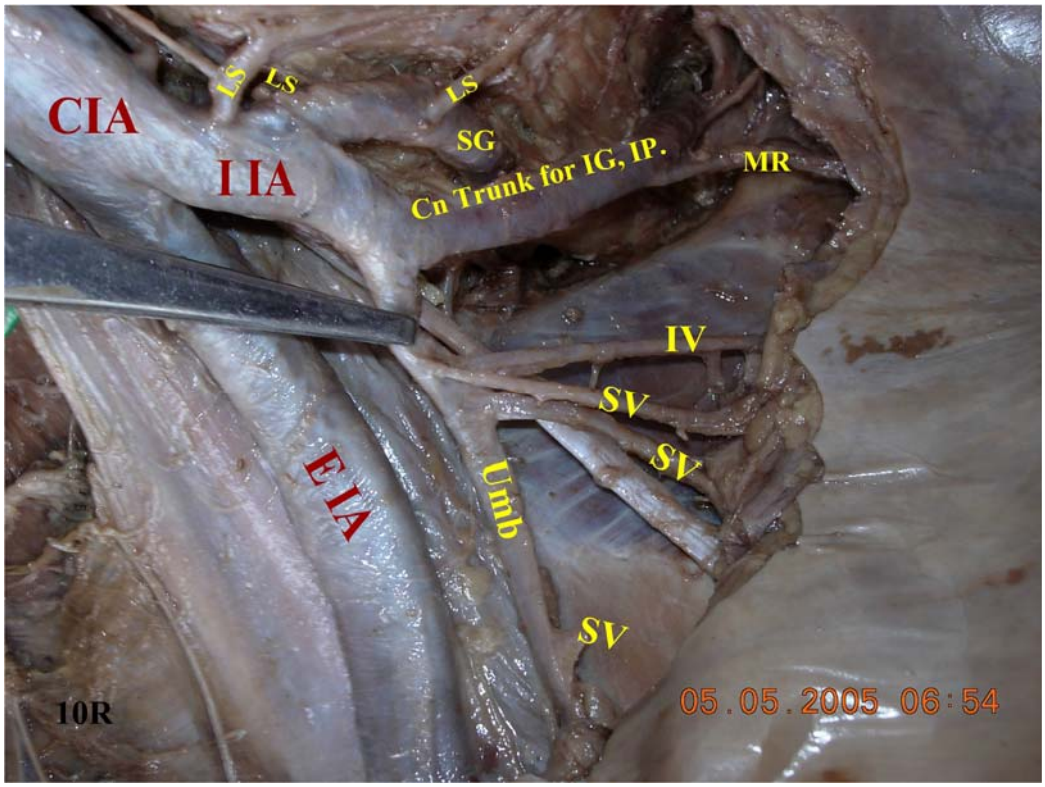
Origin	Braithwaite (1952) %	Roberts et al (1967) %	Present Study (2007) %
Anterior Division	41.4	53.2	23.7
Common trunk for inferior gluteal and internal pudendal artery	10	-	13.2
Inferior gluteal artery	4.7	-	2.6
Superior gluteal artery	10	-	5.3
Internal pudendal artery	3.8	-	2.6
Umbilical	-	-	5.3
Posterior Division	3.5	16.5	5.3
Internal iliac artery	-	3.7	-
External iliac artery	1.1	1.3	5.3
Inferior epigastric artery	19.5	25.3	31.6
Double origin	6.5		5.3

Table-35
Bilateral abnormal obturator artery:

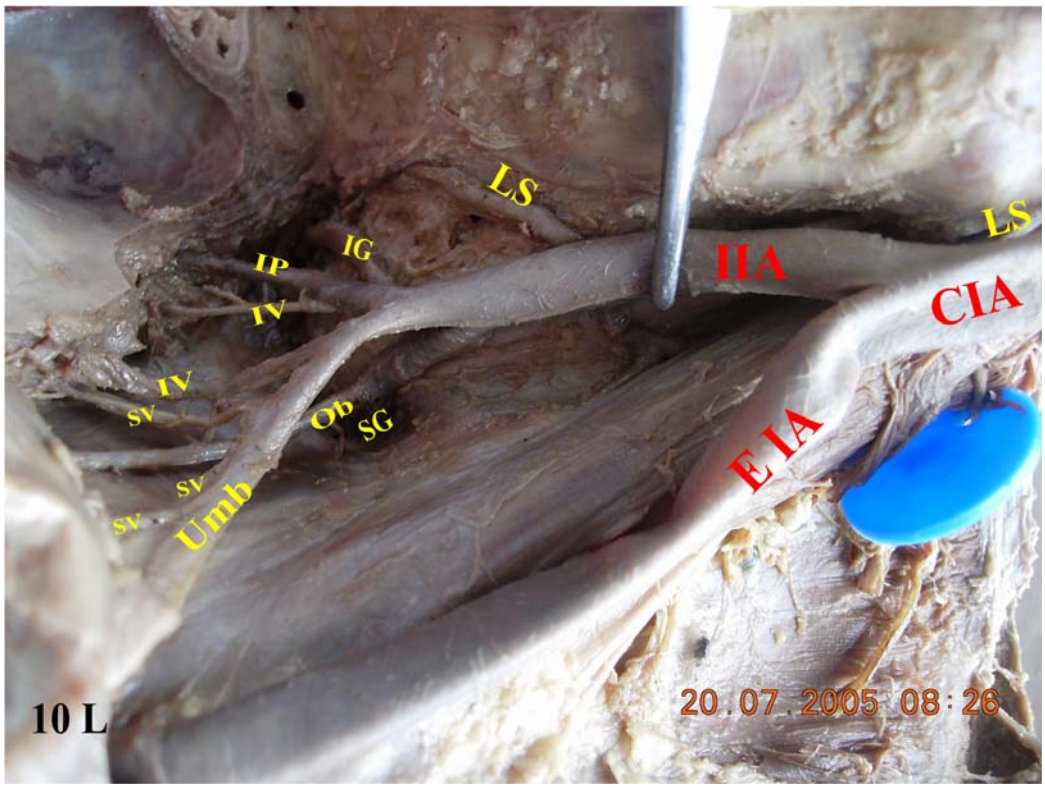
Author	Total number of pelves	Bilateral abnormal obturator artery
Cloquet	250	62
Quain	159	25
Hesselbach	32	
Pfitzner	105	
Dubreuil-Chambardel	130	41
Uni-/Bilateral Side Totals	539	128 **(23.7%)**
Present study	19	4 **(21%)**



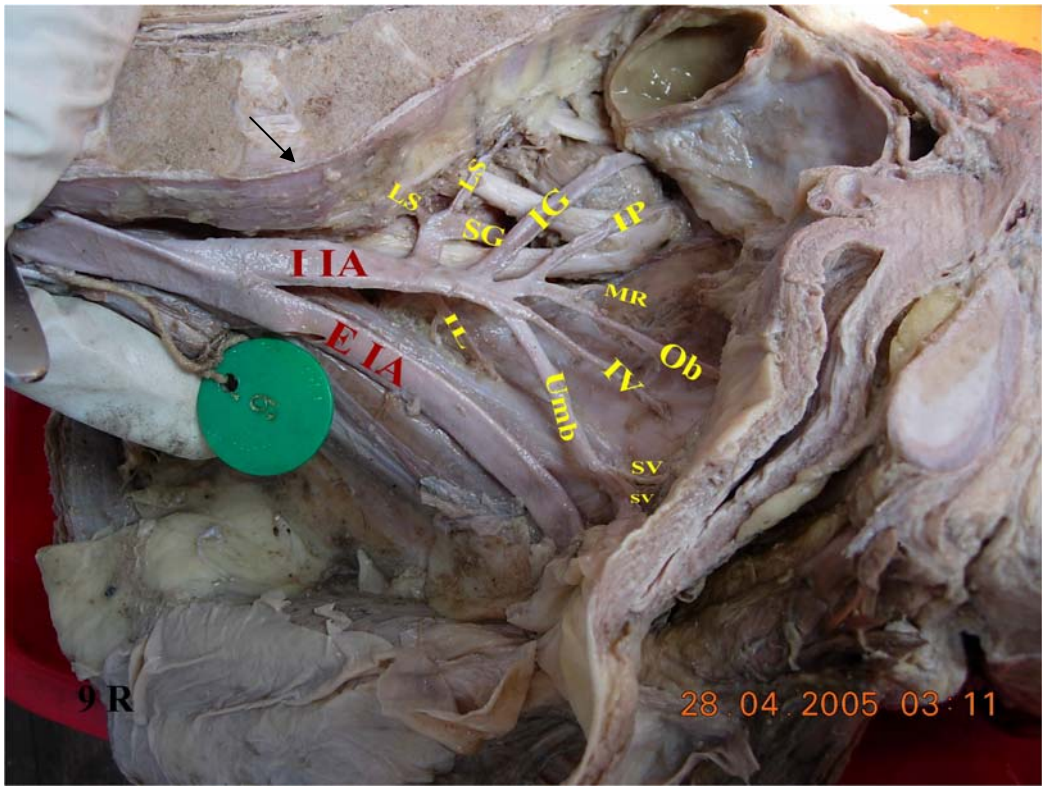
Picture 1: Internal iliac artery and its branches



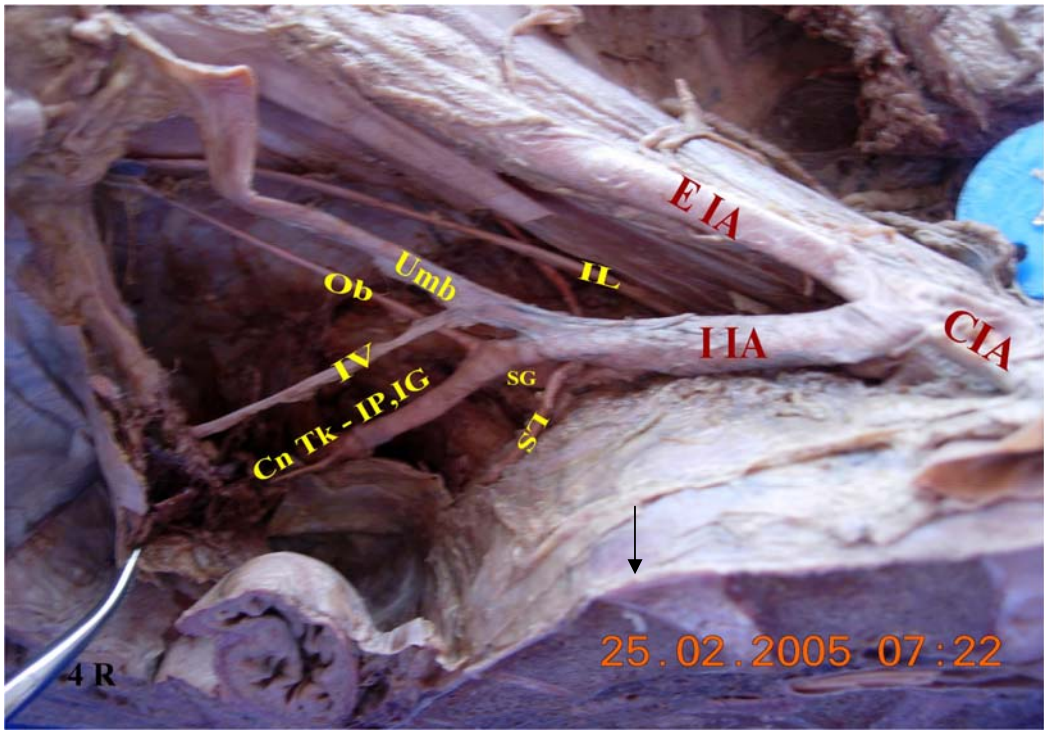
Picture 2: Short Internal iliac artery



Picture 3: Long Internal iliac artery

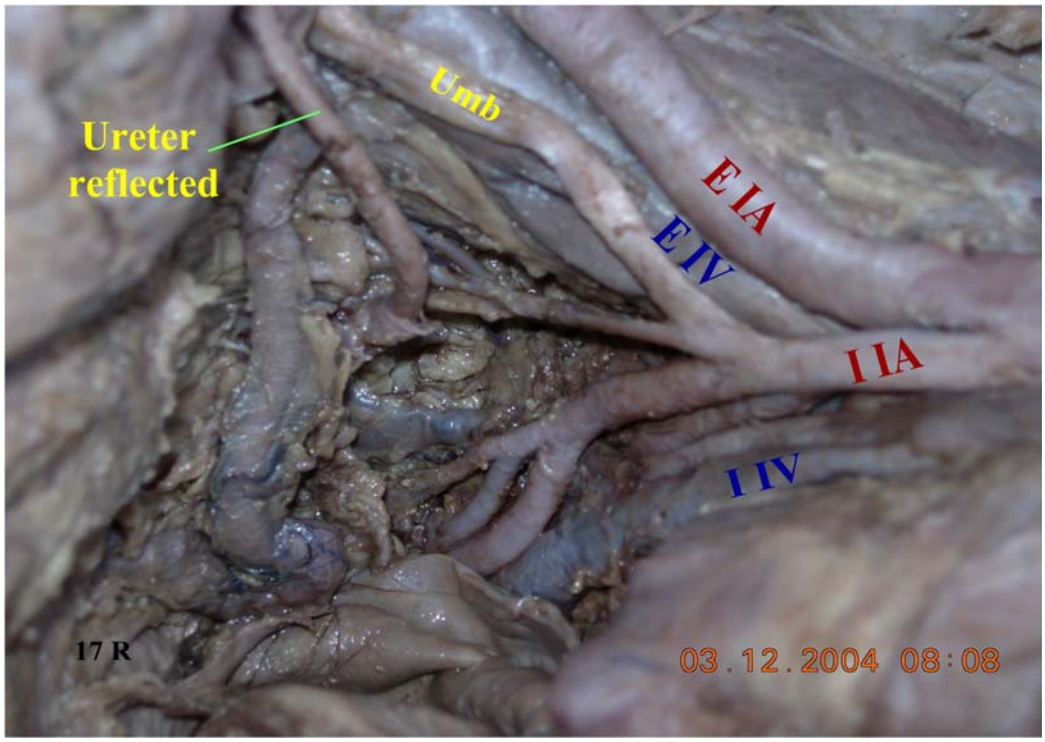


Picture 4: Origin of Internal iliac artery at the level of Lumbosacral articulation

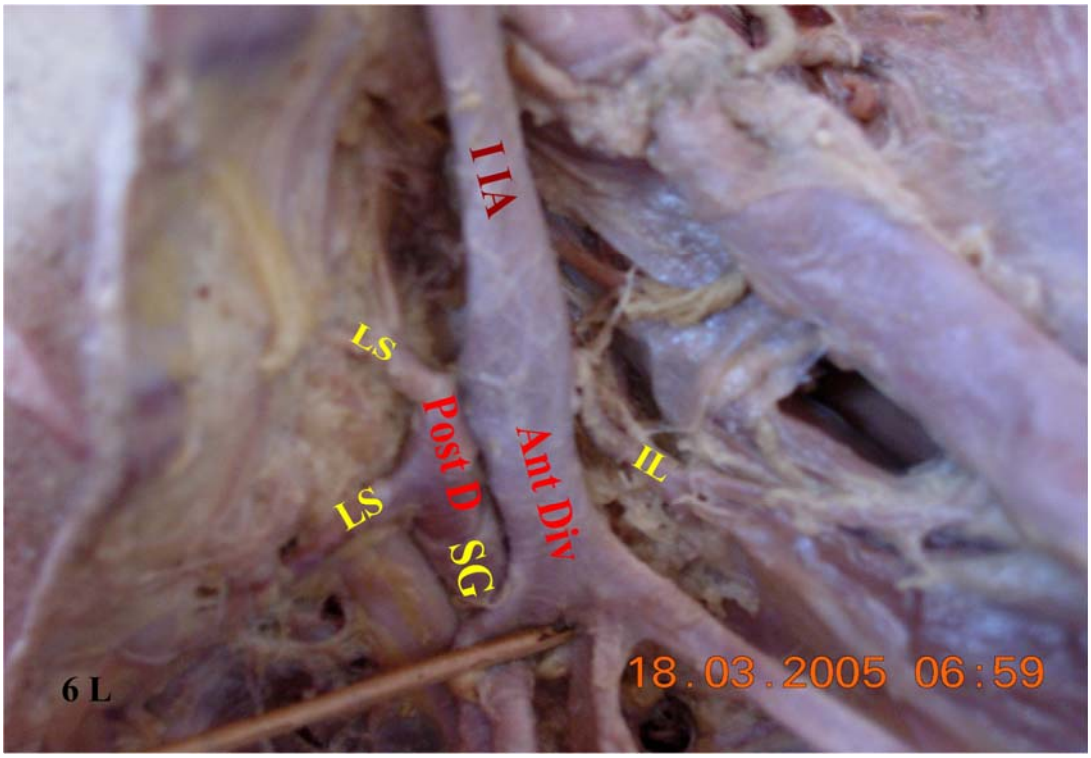


Picture 5: Origin of Internal iliac artery above the level of Lumbosacral articulation

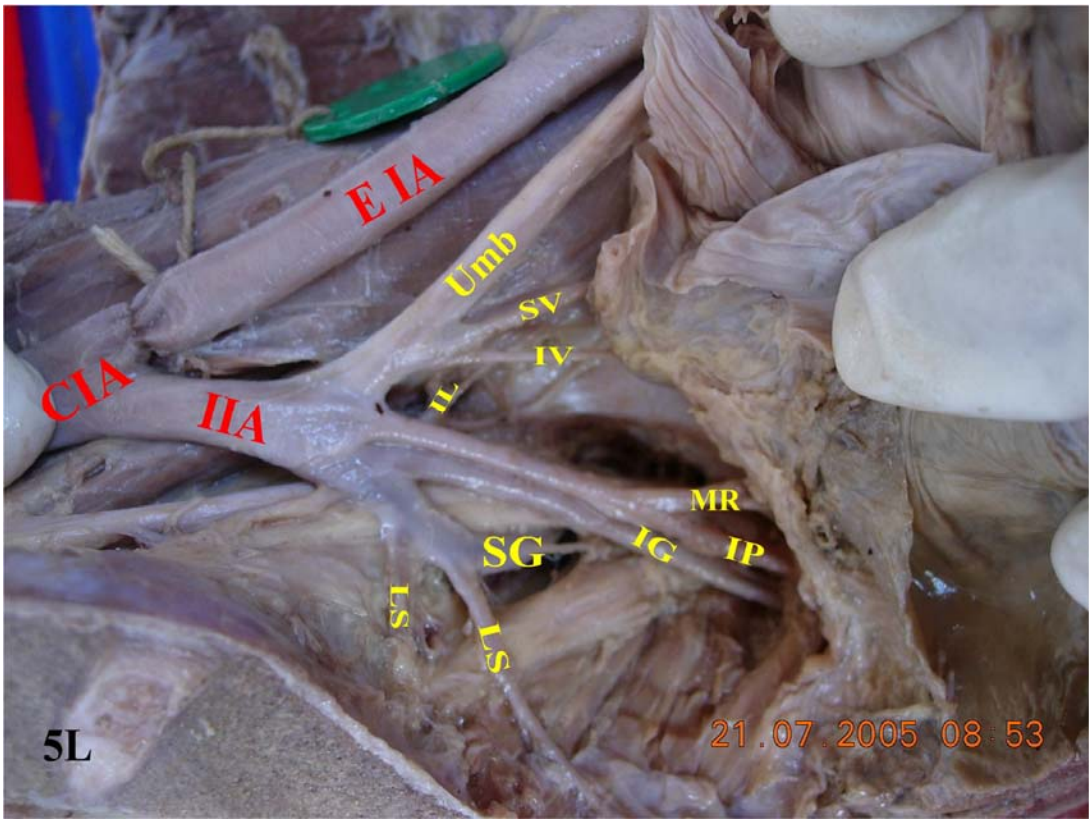
Picture 6: Relationship of Internal iliac artery to Ureter



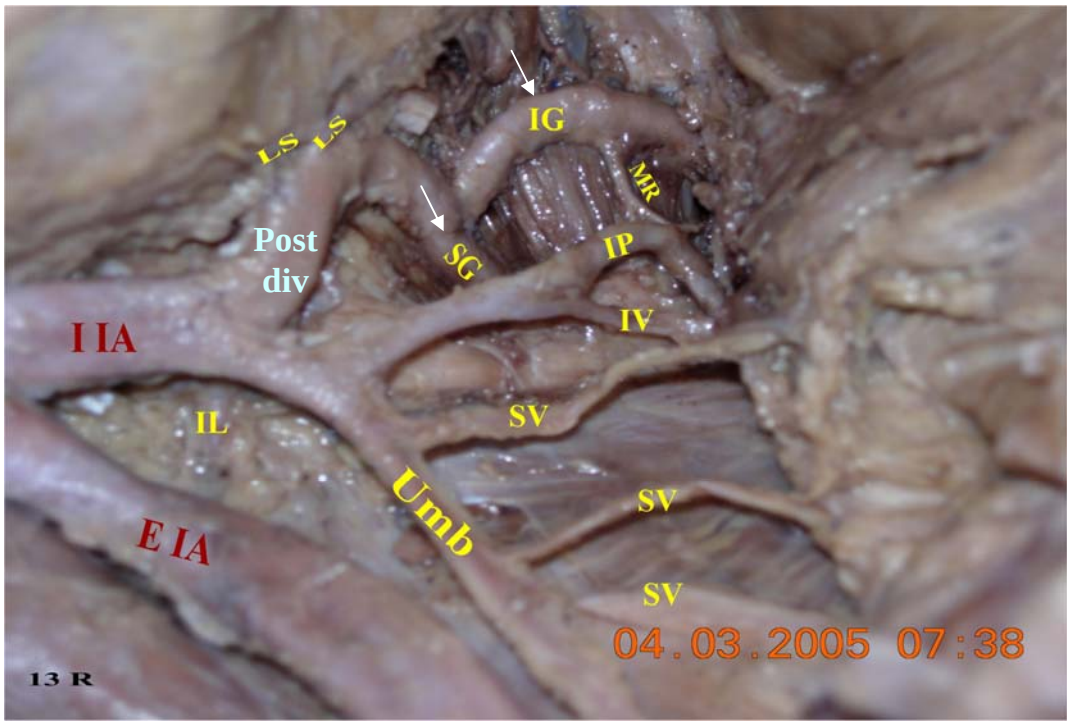
Picture 7: Relationship of Internal iliac artery to internal iliac vein



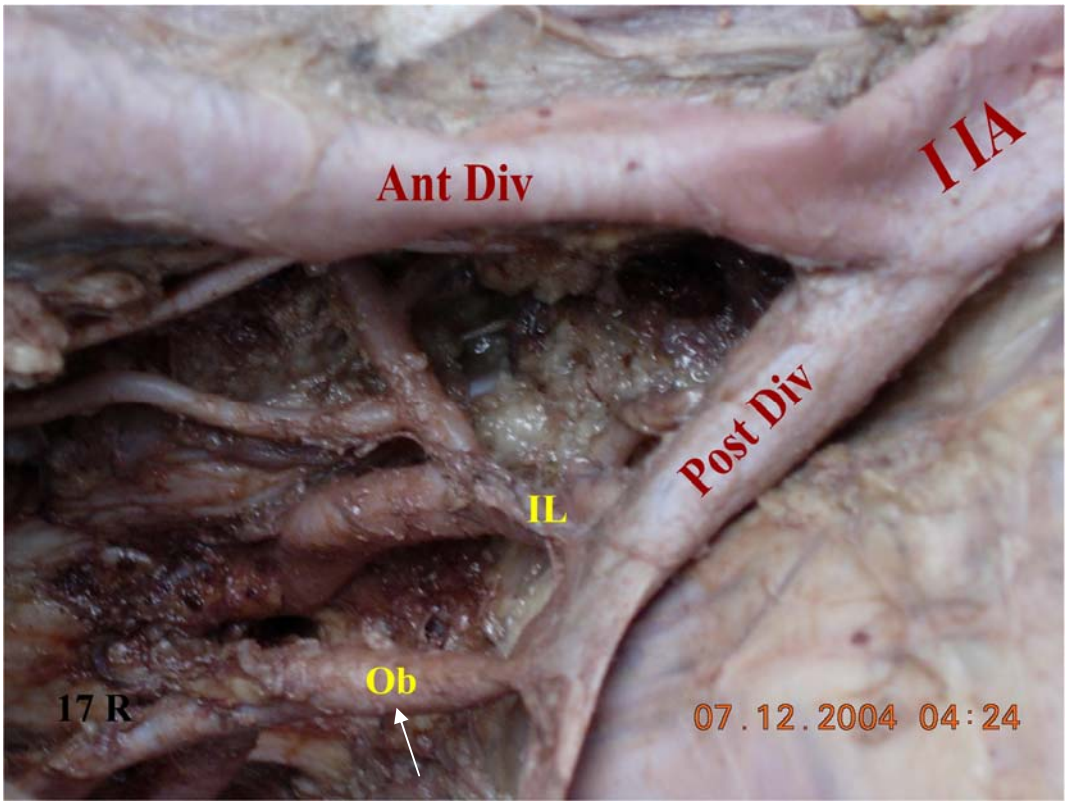
Picture 8: Division of Internal iliac artery



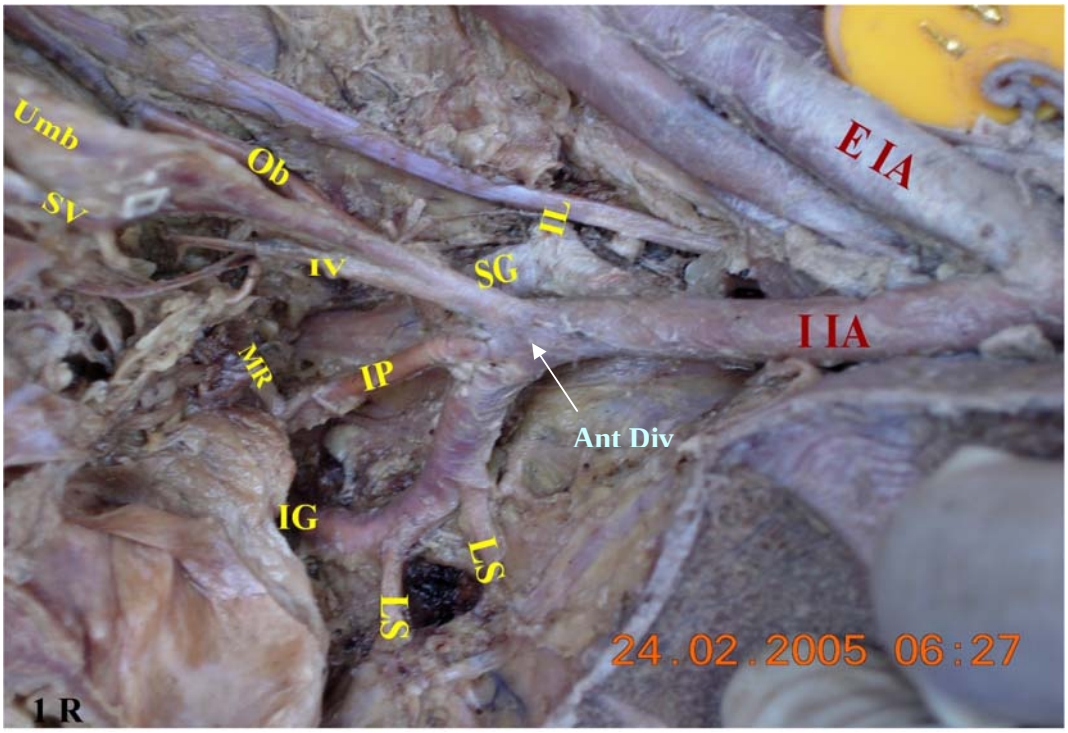
Picture 9: Internal iliac artery giving rise to terminal branches without dividing into anterior and posterior trunks.



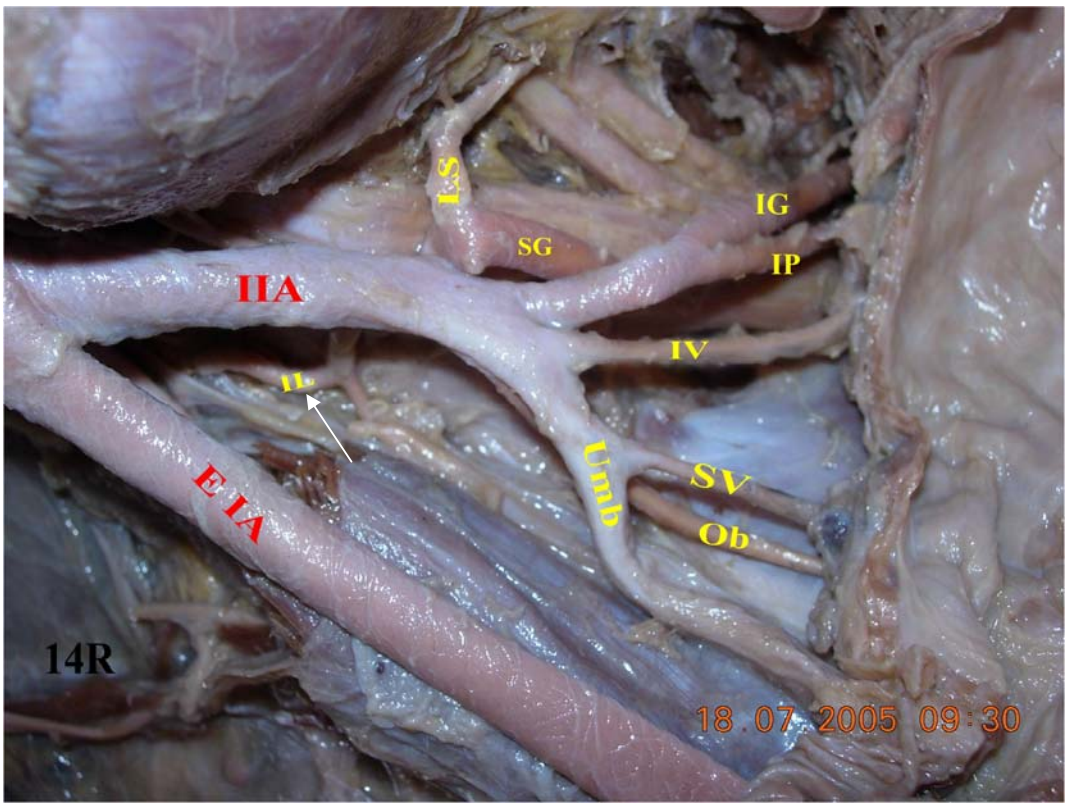
Picture 10: Inferior gluteal artery arising in common with Superior gluteal artery from posterior division



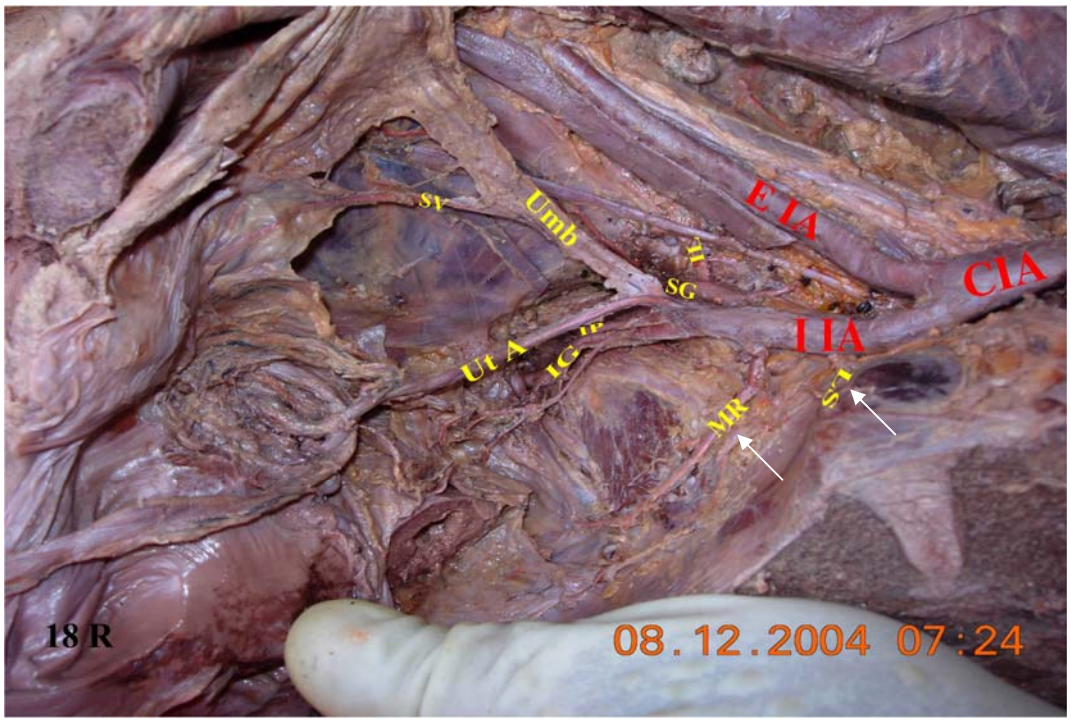
Picture 11: Obturator artery arising from posterior division



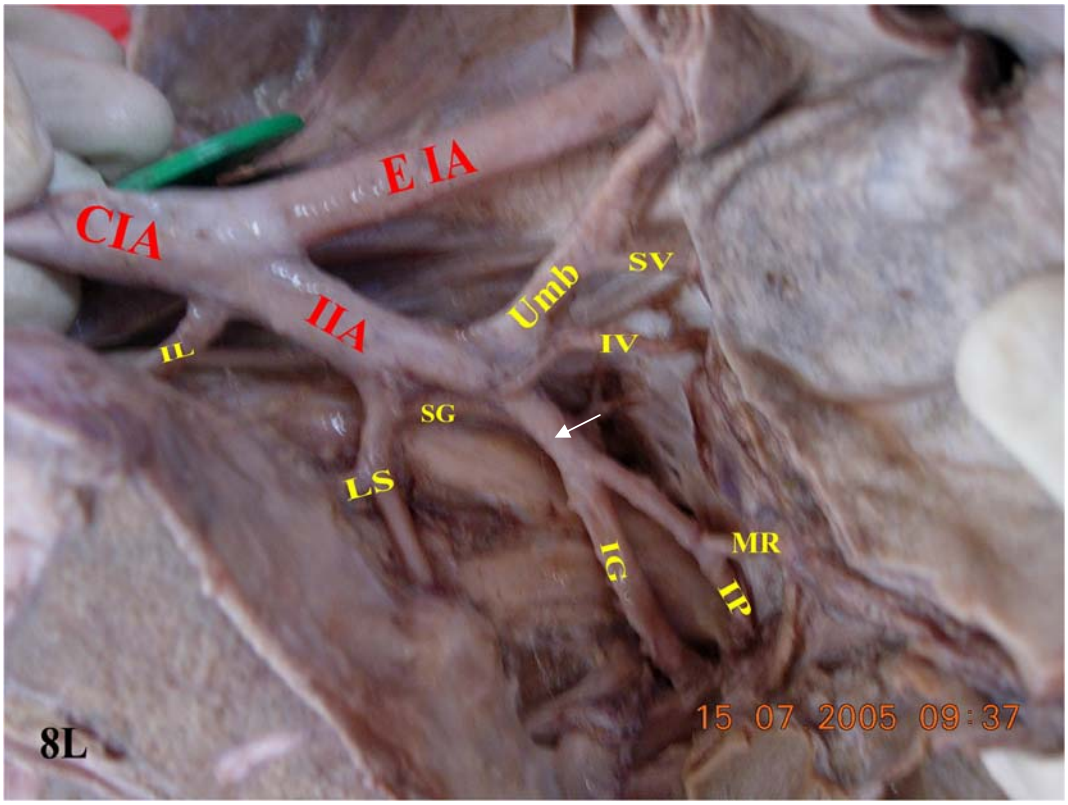
Picture 12: Lateral sacral artery arising from anterior division



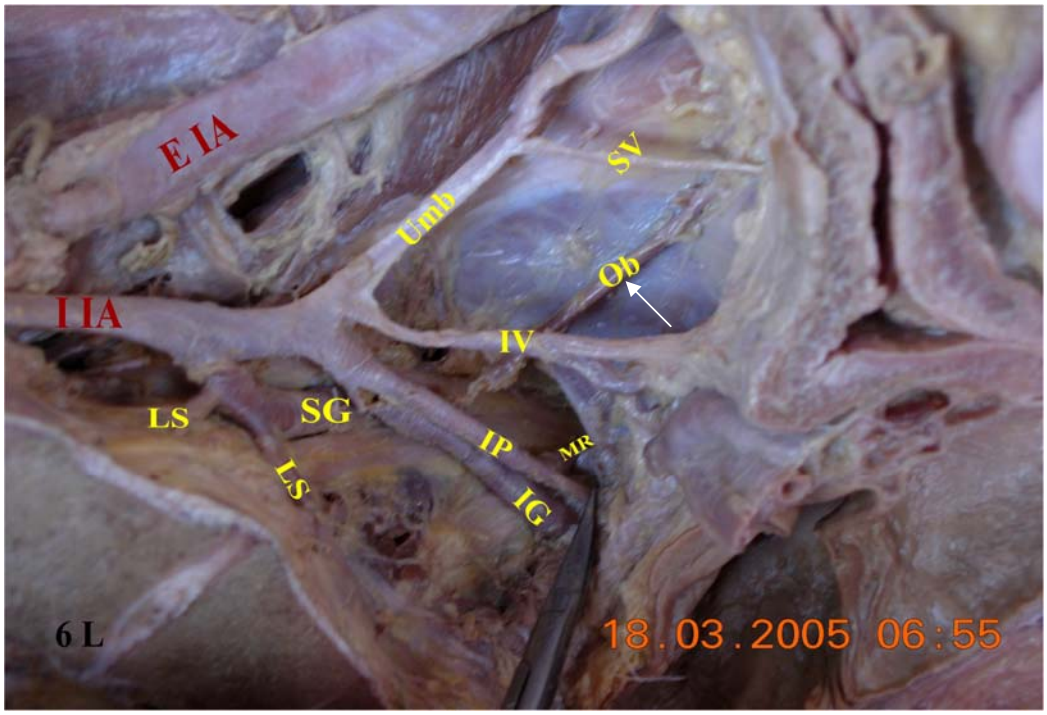
Picture 13: Iliolumbar artery arising from main stem before its division



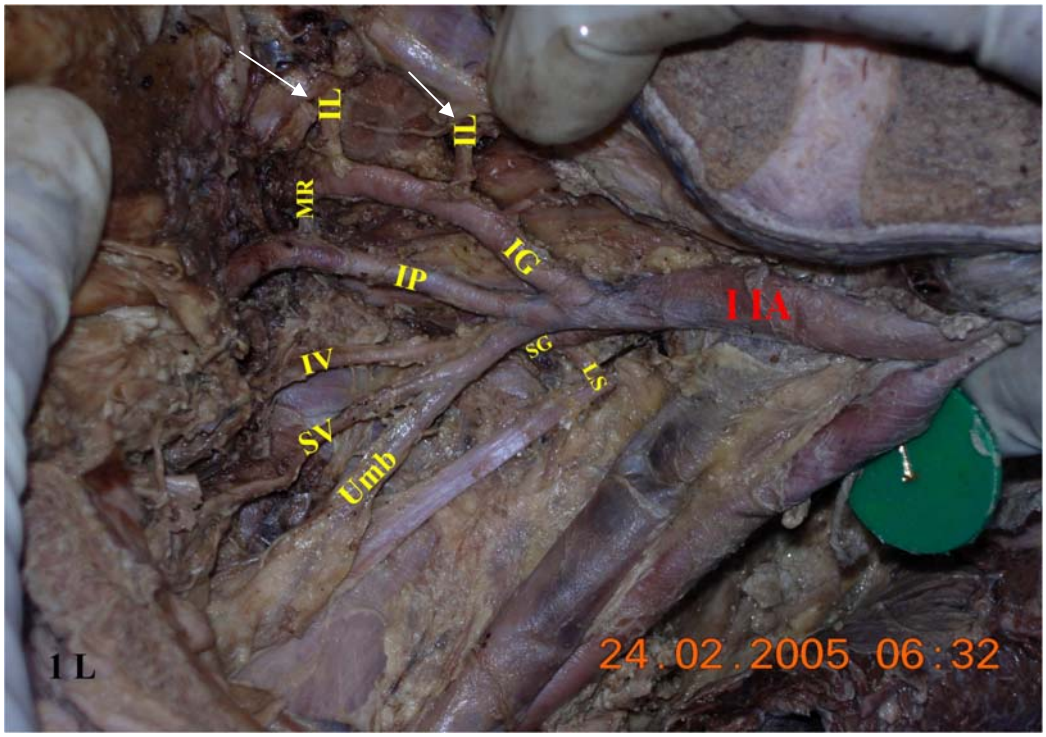
Picture 14: Lateral sacral artery and Middle rectal artery from the main stem



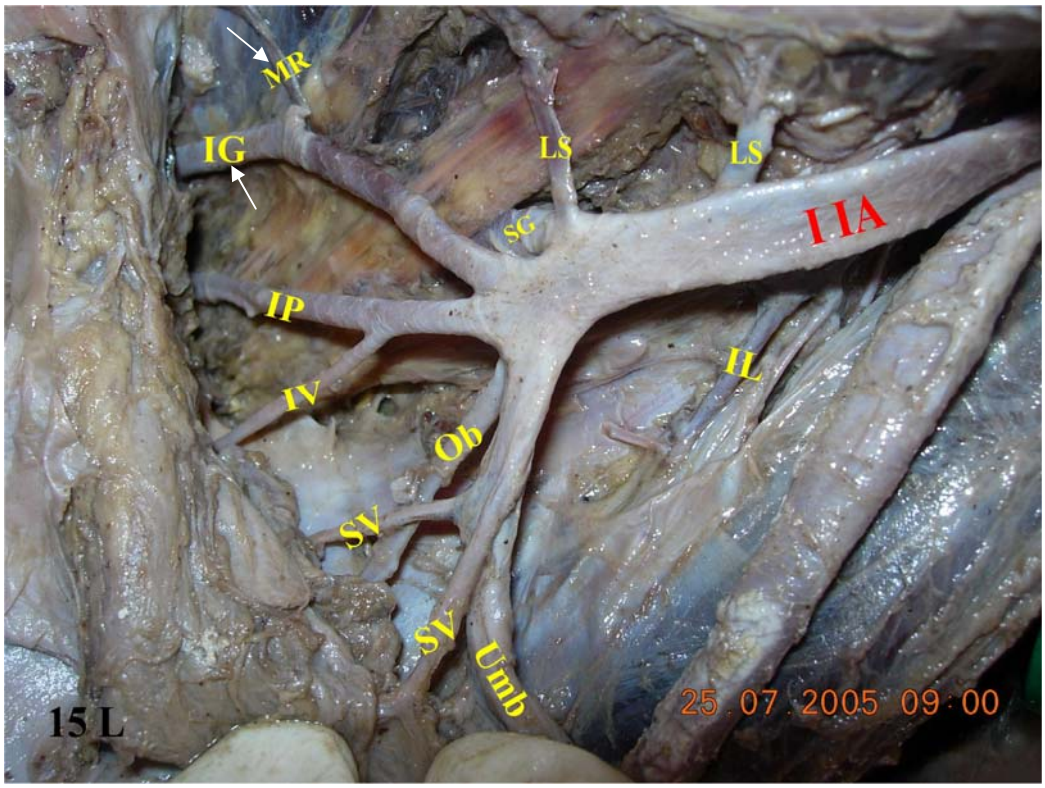
Picture 15: Common trunk for Inferior gluteal artery and Internal pudendal artery divides proximal to pelvic floor



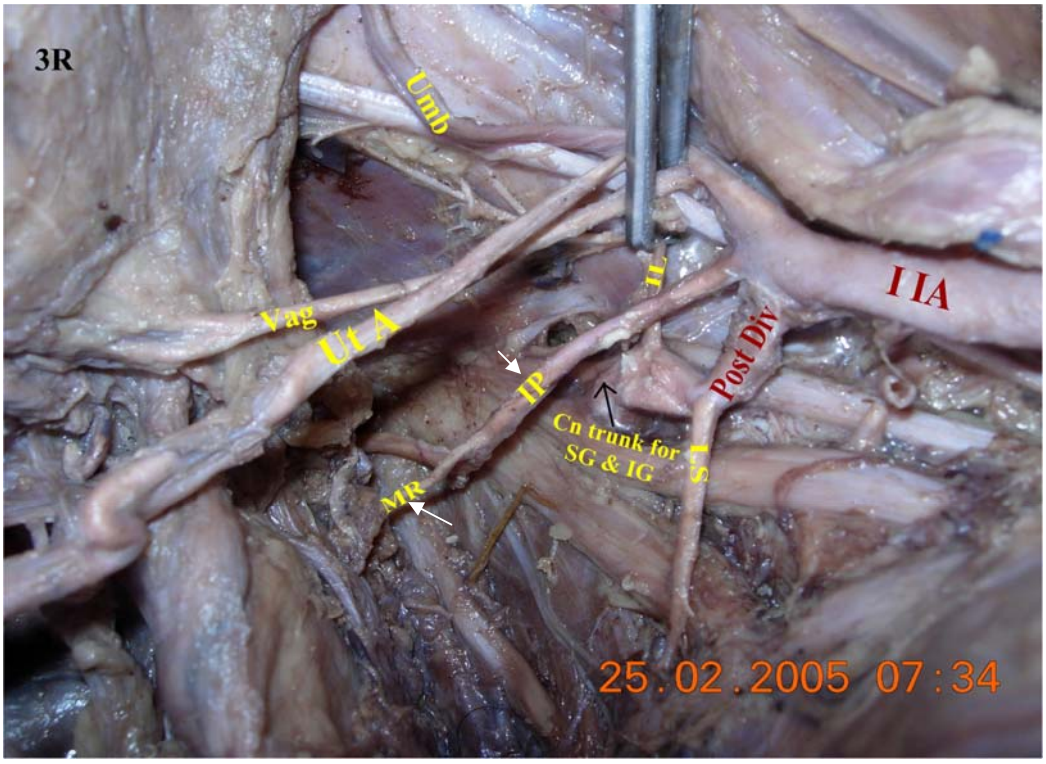
Picture 16: Obturator artery arising in common with Inferior gluteal artery



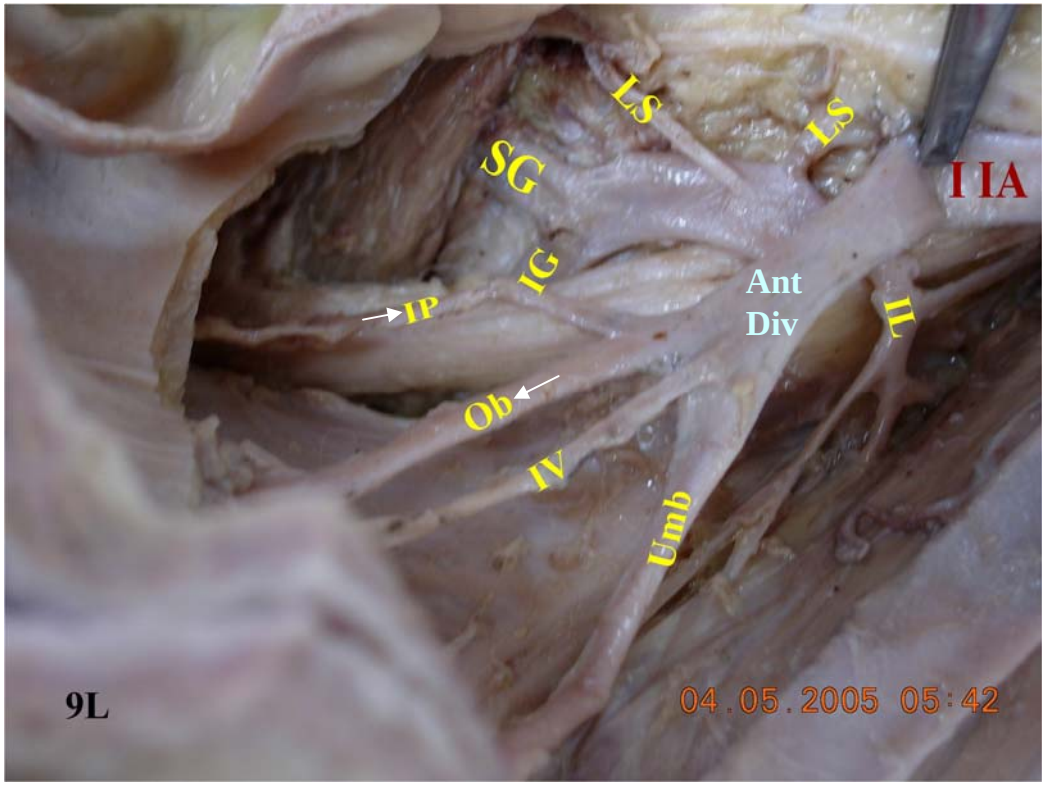
Picture 17: Iliolumbar artery arising in common with Inferior gluteal artery



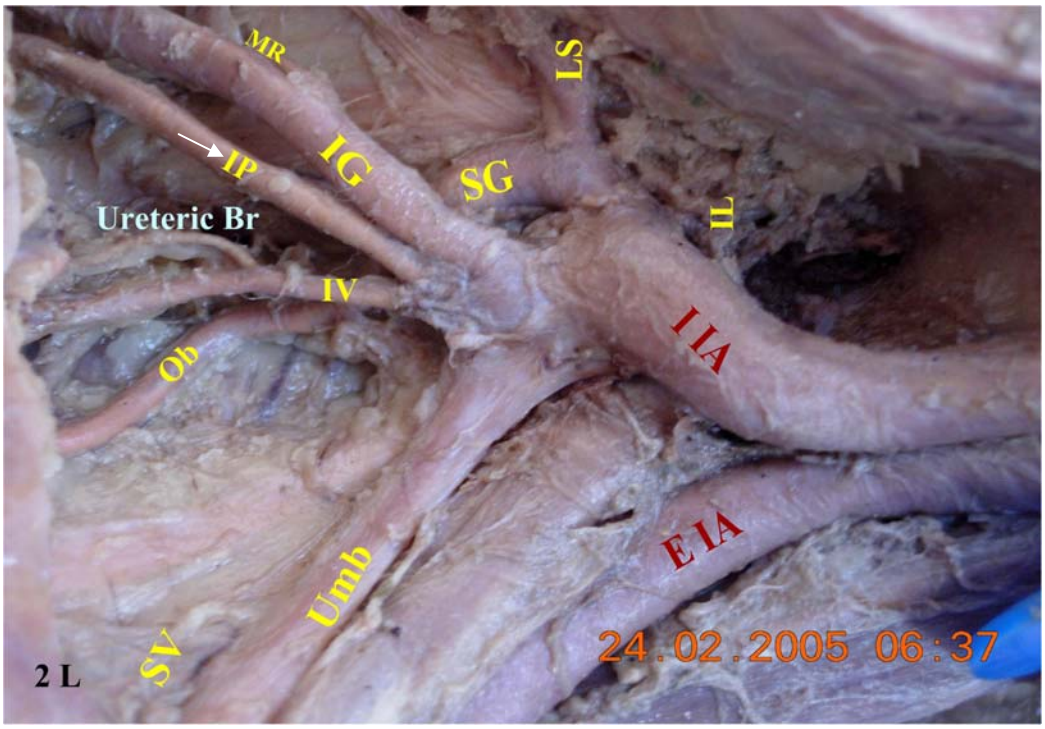
Picture 18: Inferior gluteal artery in common with Middle rectal artery from Internal iliac artery



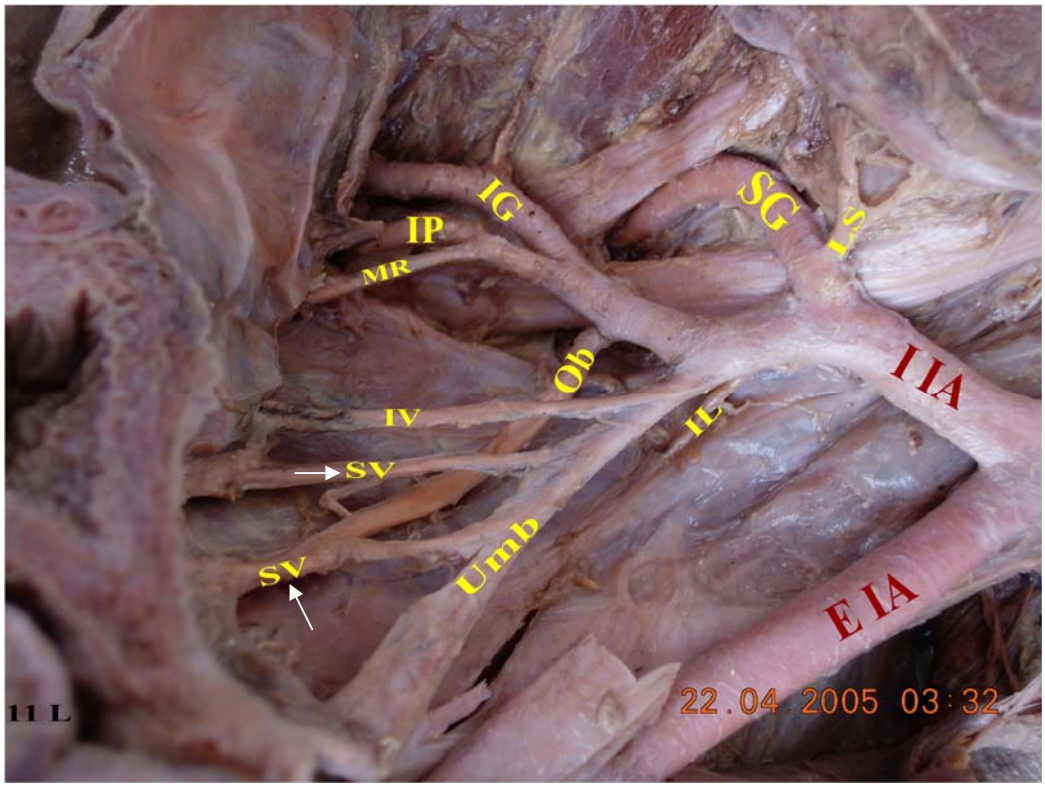
Picture 19: Internal pudendal artery in common with Middle rectal artery



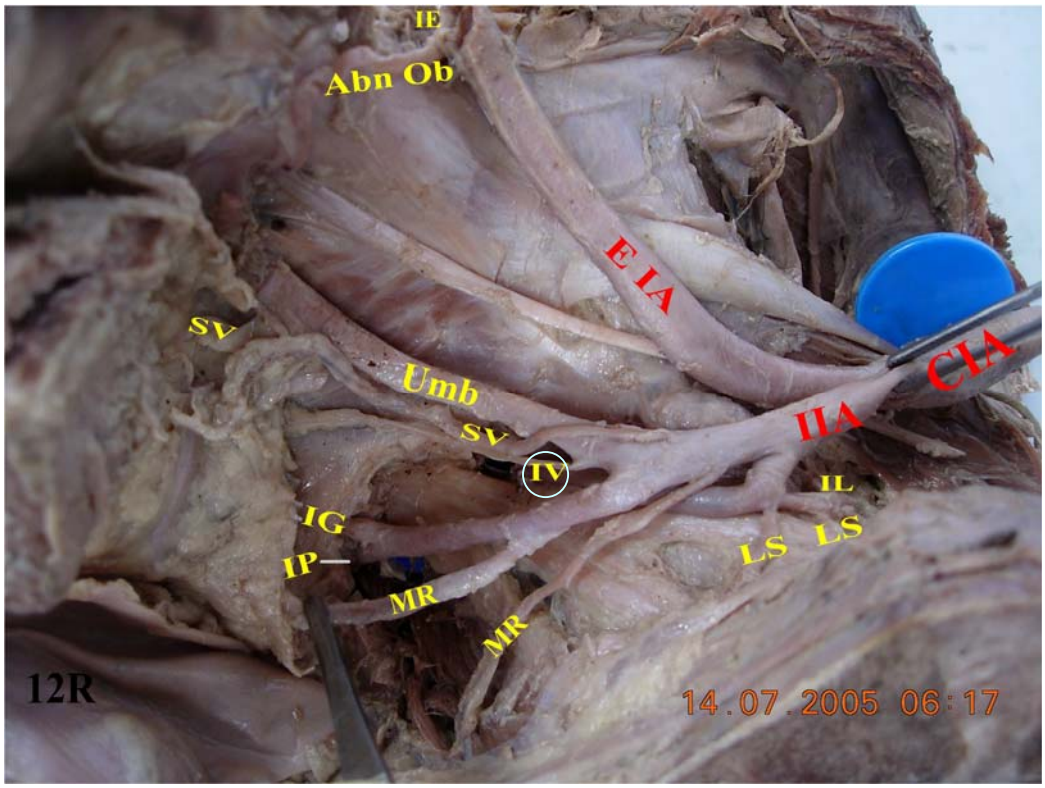
Picture 20: Internal pudendal artery and Obturator artery from anterior division



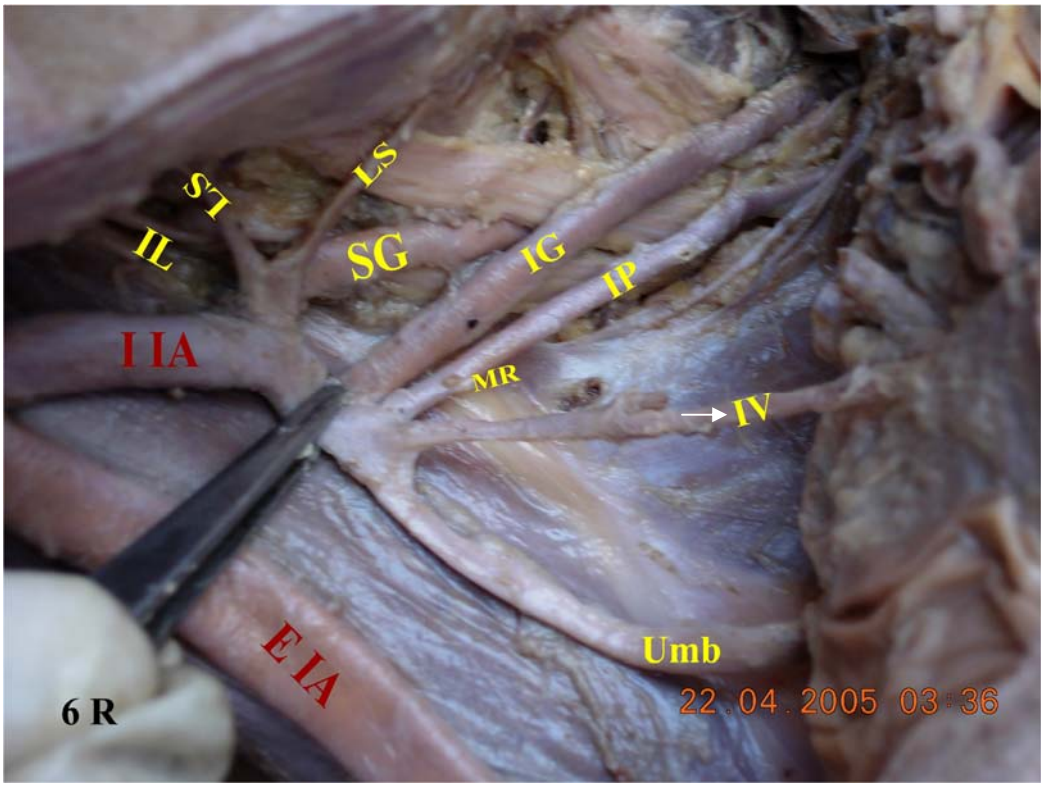
Picture 21: Internal pudendal artery from Internal iliac artery



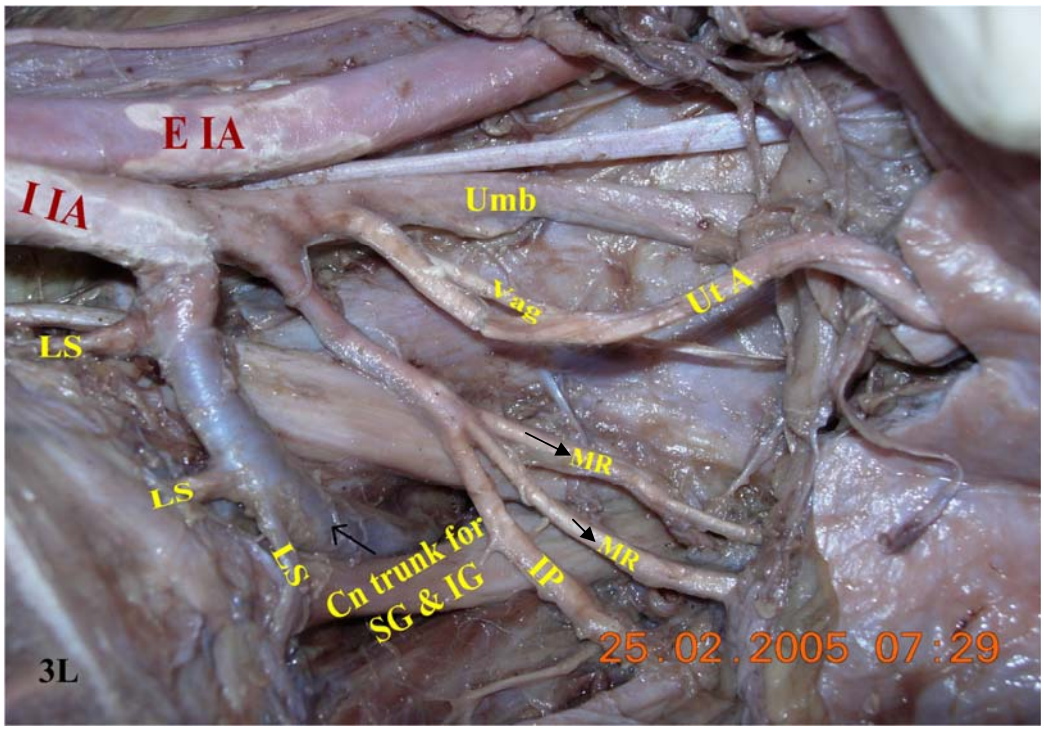
Picture 22: Two Superior vesical arteries



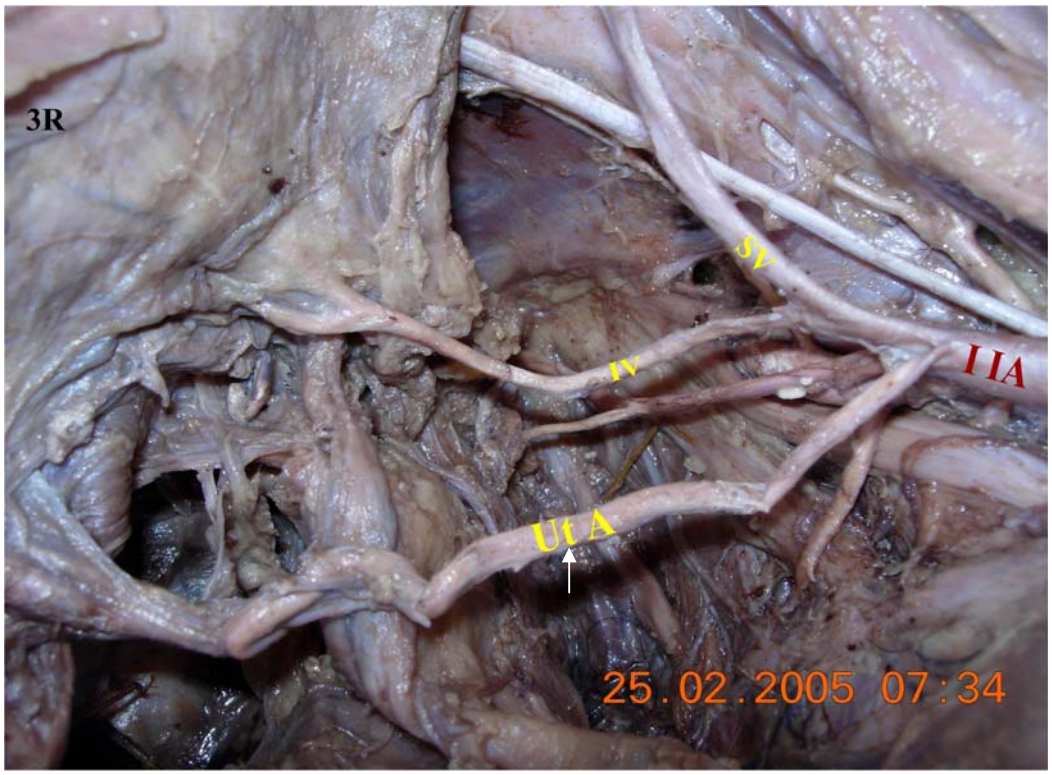
Picture 23: Inferior vesical artery from Umbilical artery



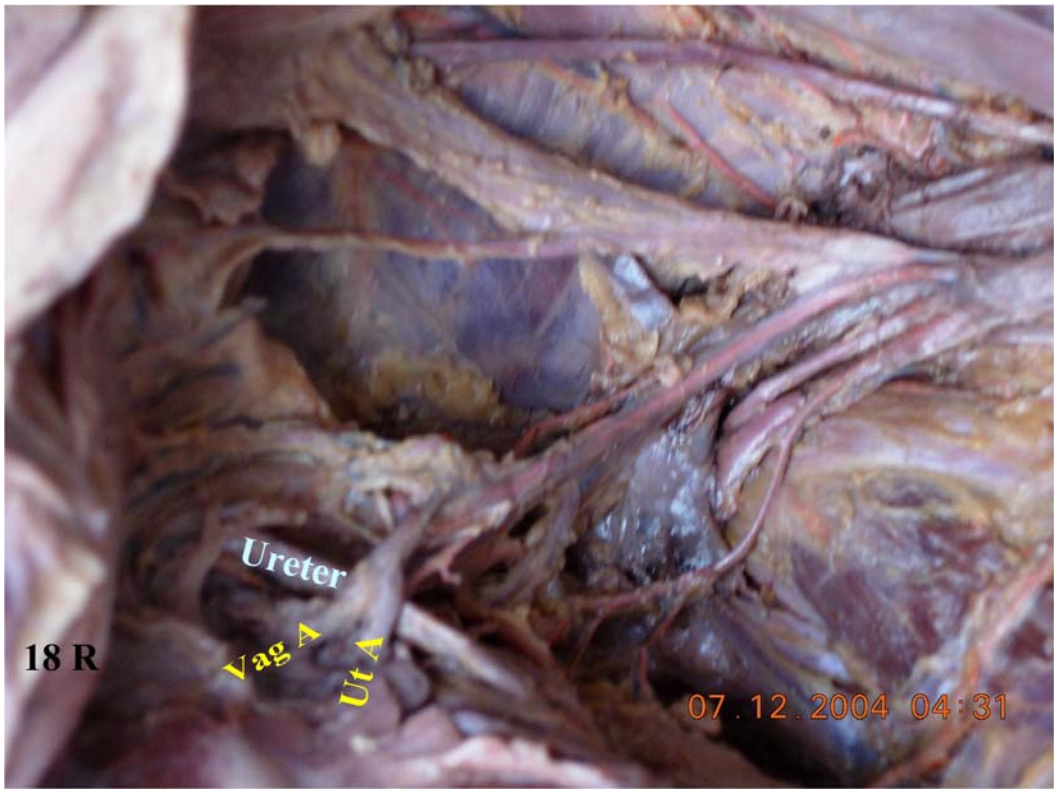
Picture 24: Inferior vesical artery from Internal iliac artery



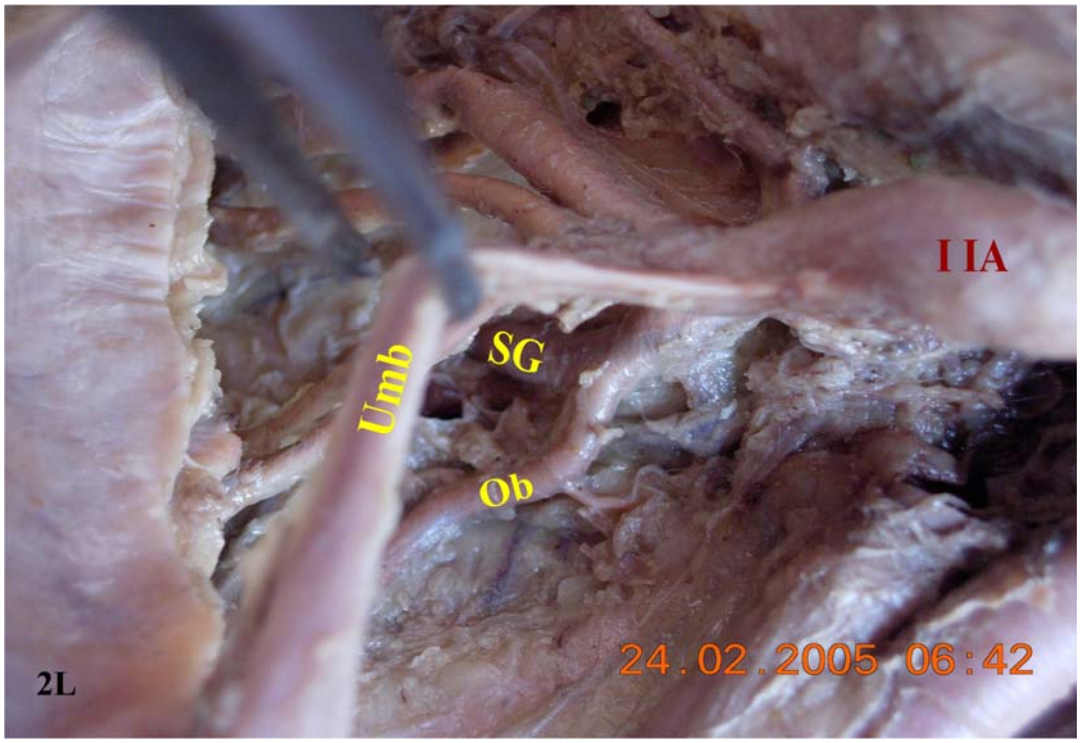
Picture 25: Two middle rectal arteries in common with Internal pudendal artery



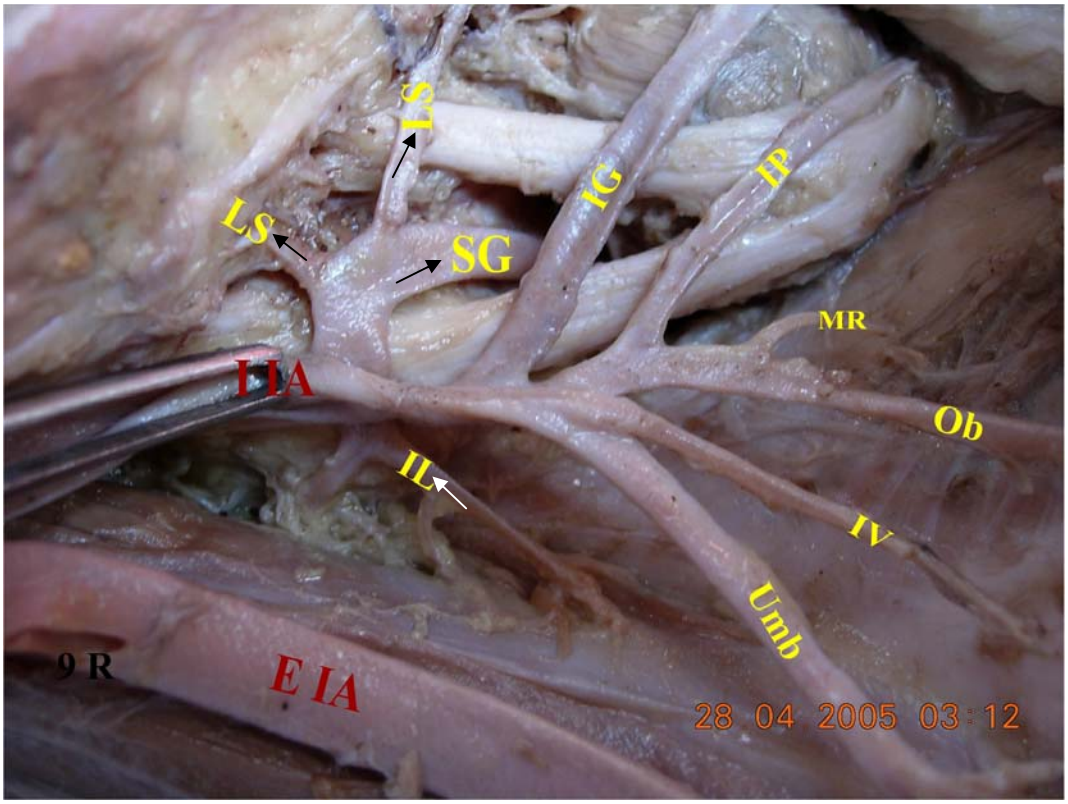
Picture 26: Uterine artery arising from anterior division



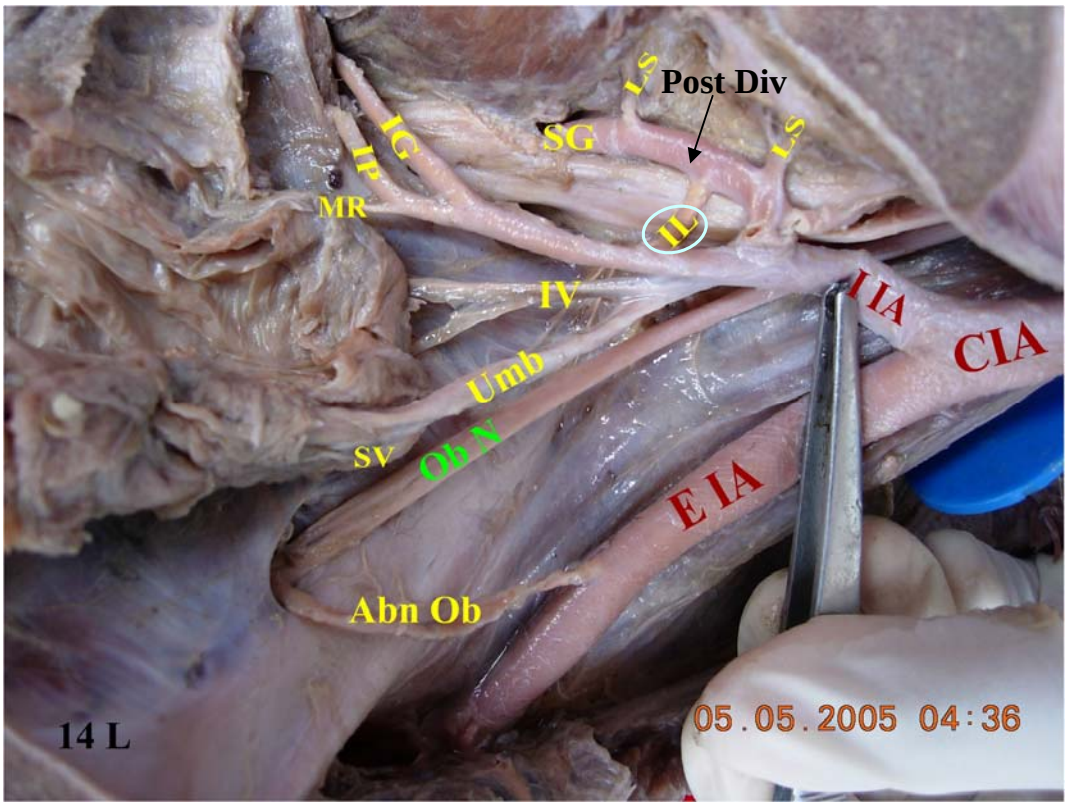
Picture 27: Uterine artery in relation to Ureter



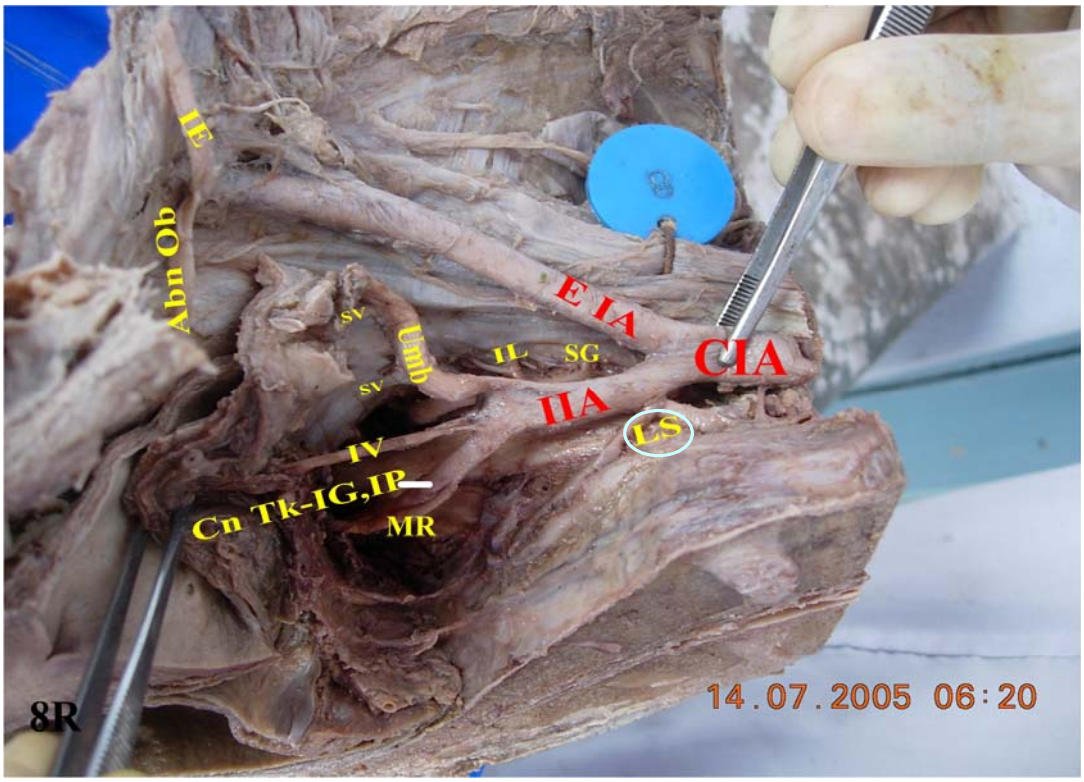
Picture 28: Superior gluteal artery in common with Obturator artery



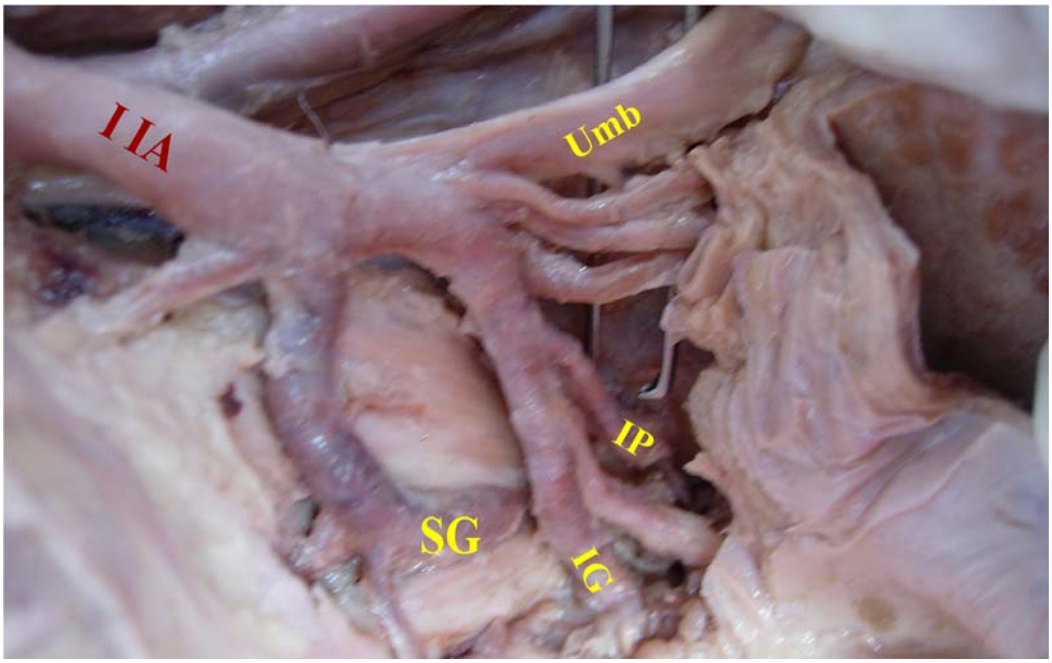
Picture 29: Superior gluteal artery with Lateral sacral artery and Iliolumbar artery from Internal iliac artery



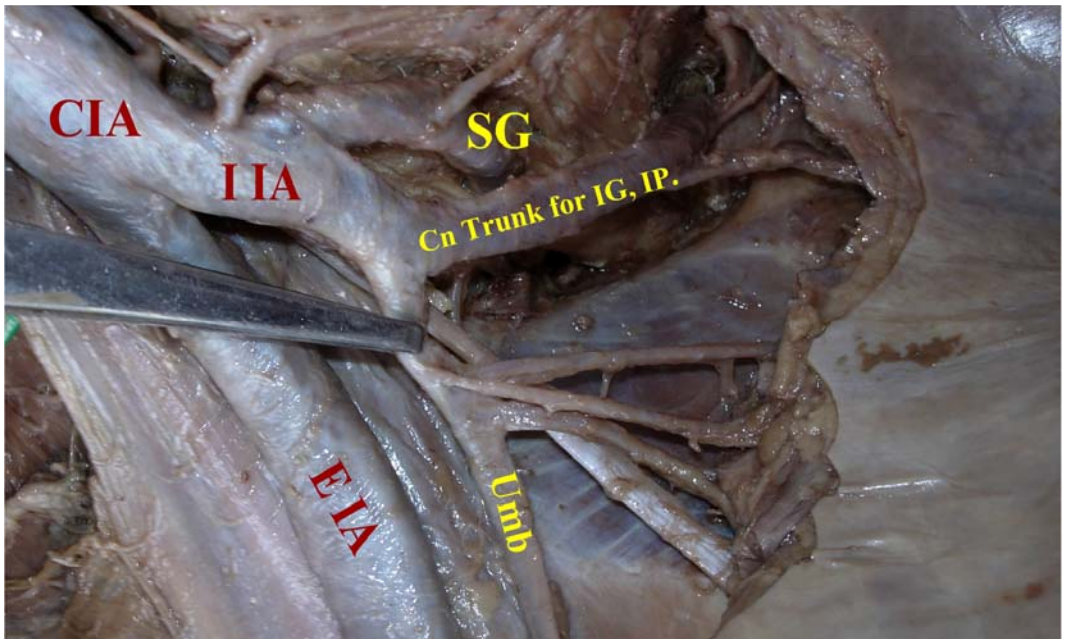
Picture 30: Iliolumbar artery from posterior division



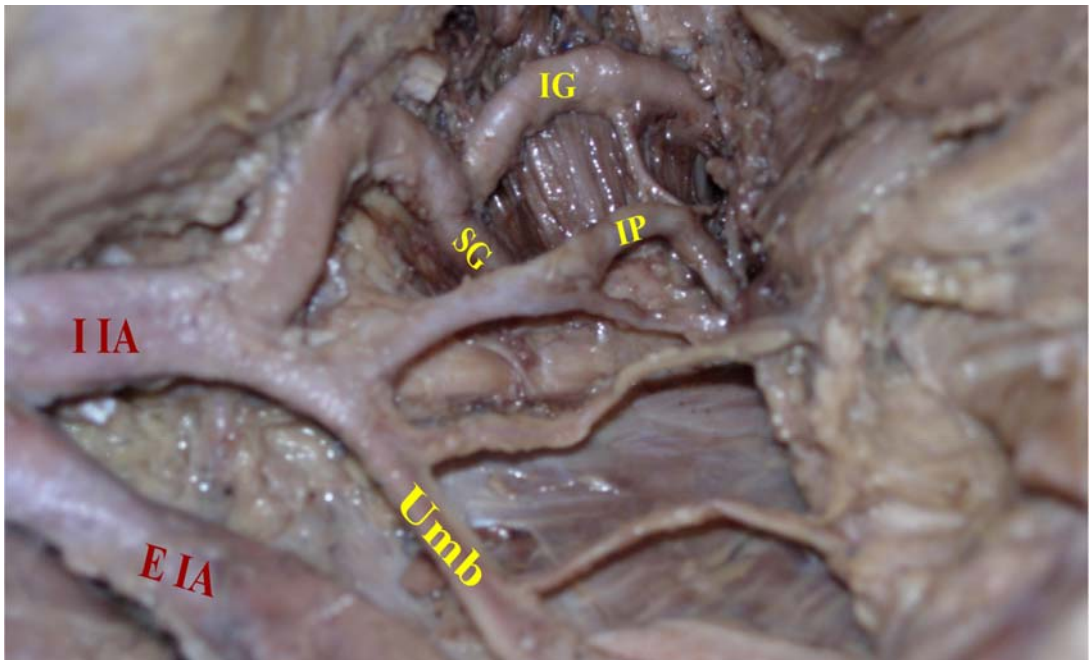
Picture 31: Single Lateral sacral artery



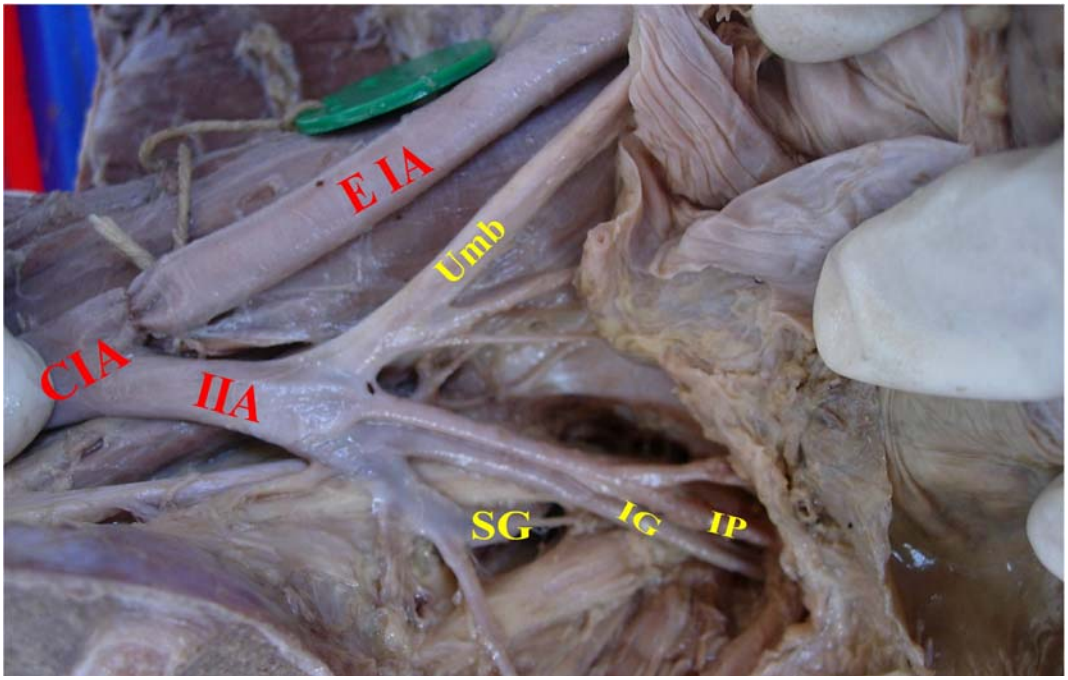
Picture 32: Type Ia Adachi's classification (superior gluteal artery arises separately from internal iliac artery and a common trunk for inferior gluteal artery and internal pudendal artery divides proximal to the pelvic floor)



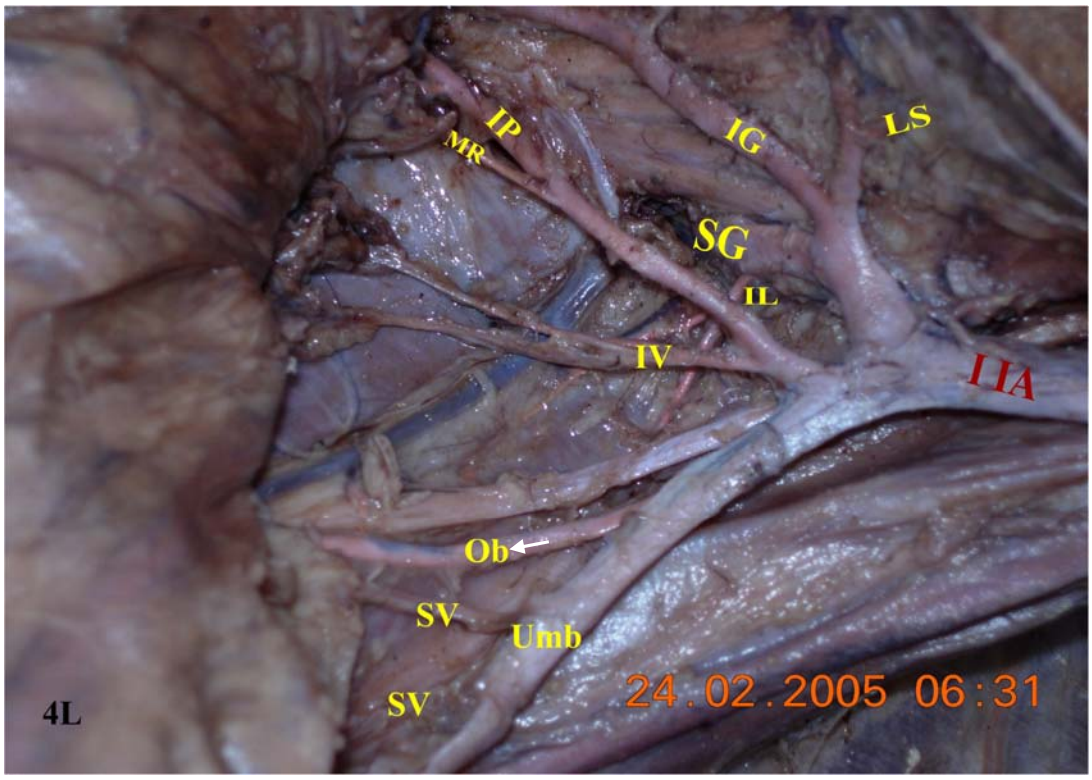
Picture 33: Type Ib Adachi's classification (superior gluteal artery arises separately from internal iliac artery and a common trunk for inferior gluteal artery and internal pudendal artery divides distal to the pelvic floor)



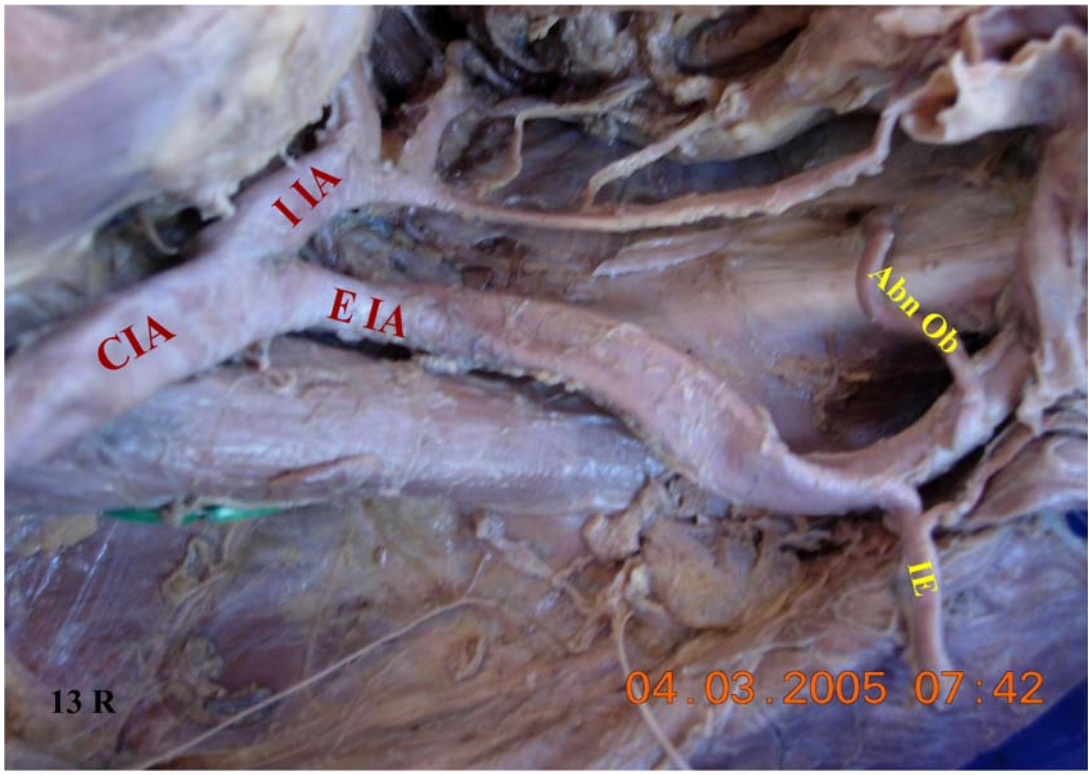
Picture 34: Type IIa Adachi's classification (Internal pudendal artery arises separately from internal iliac artery while inferior gluteal artery and superior gluteal artery arise by a common trunk which divides proximal to the pelvic floor)



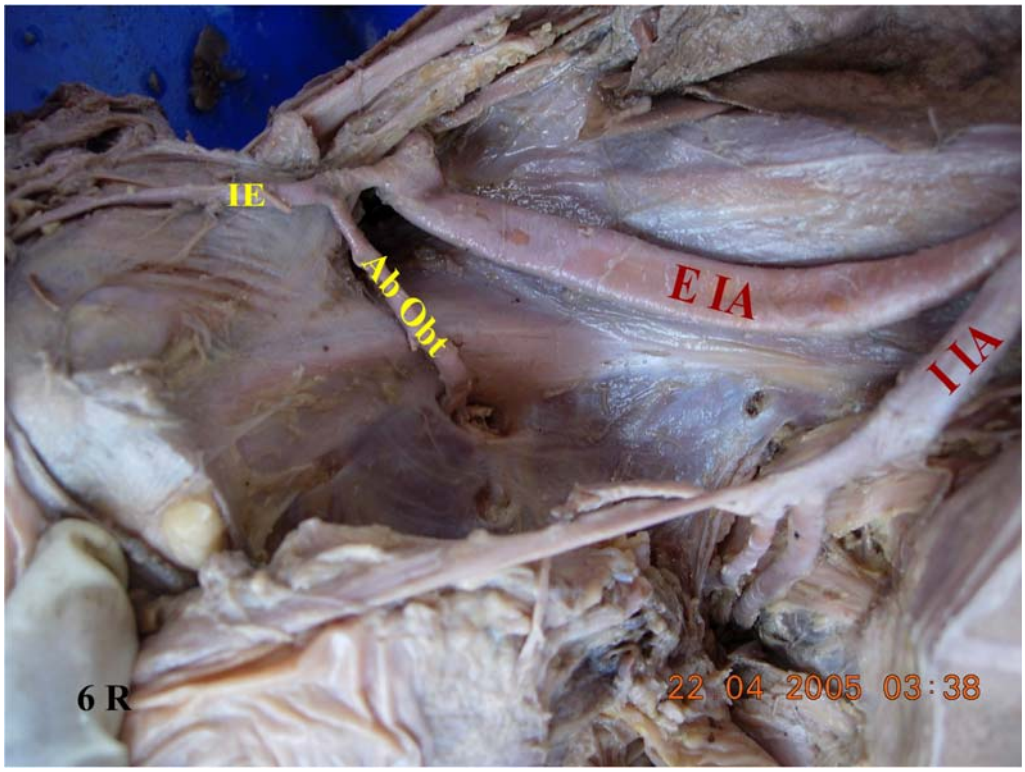
Picture 35: Type III Adachi's classification (The three branches namely inferior gluteal, superior gluteal and internal pudendal artery arise separately from the internal iliac artery)



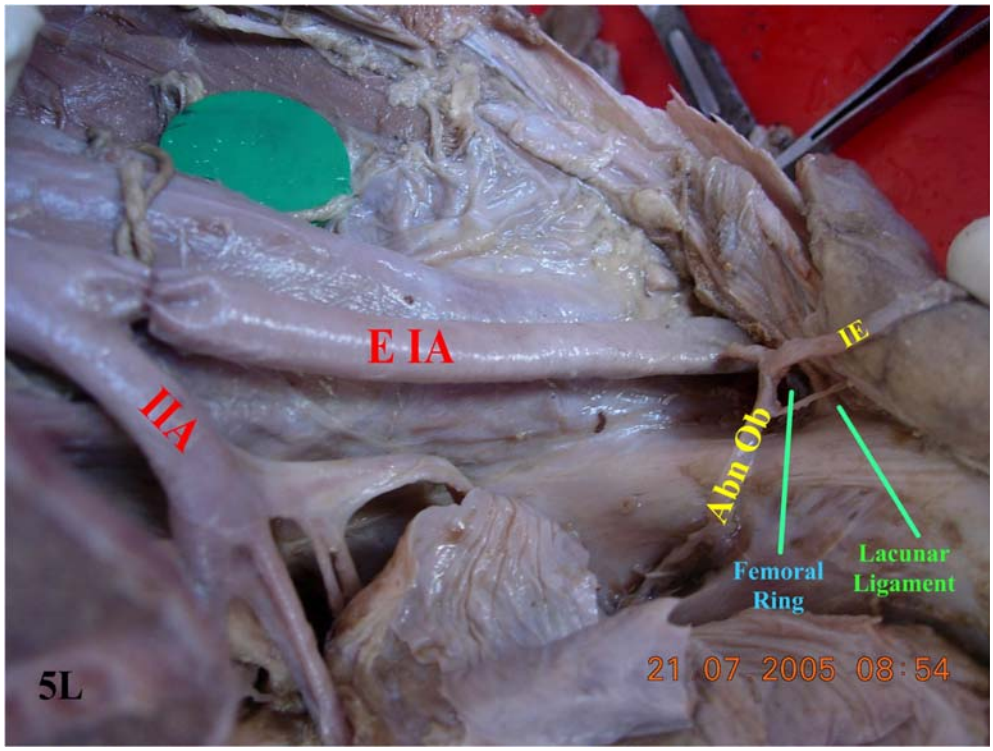
Picture 36: Obturator artery from Umbilical artery



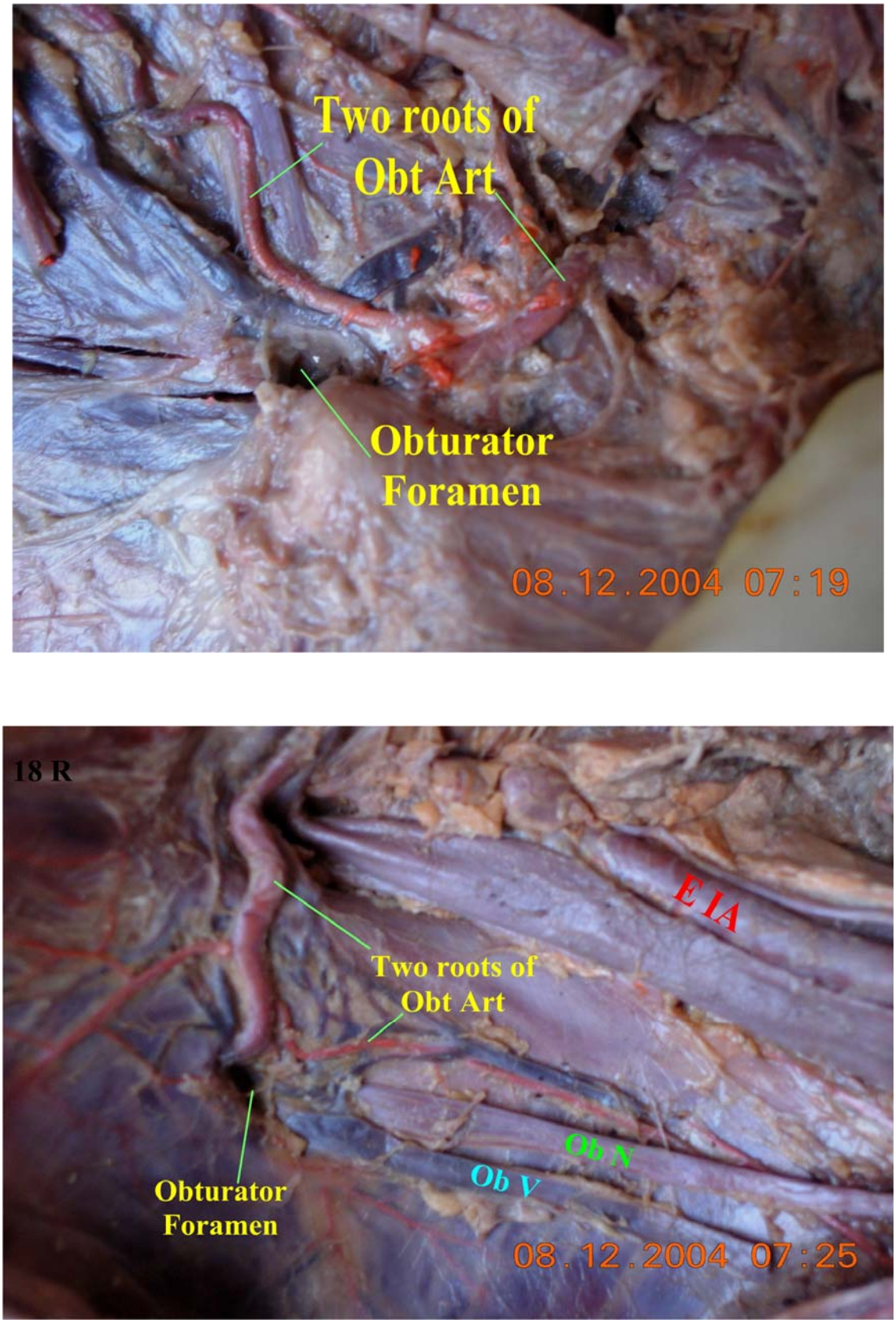
Picture 37: Abnormal Obturator artery from External iliac artery



Picture 38: Abnormal Obturator artery from Inferior epigastric artery

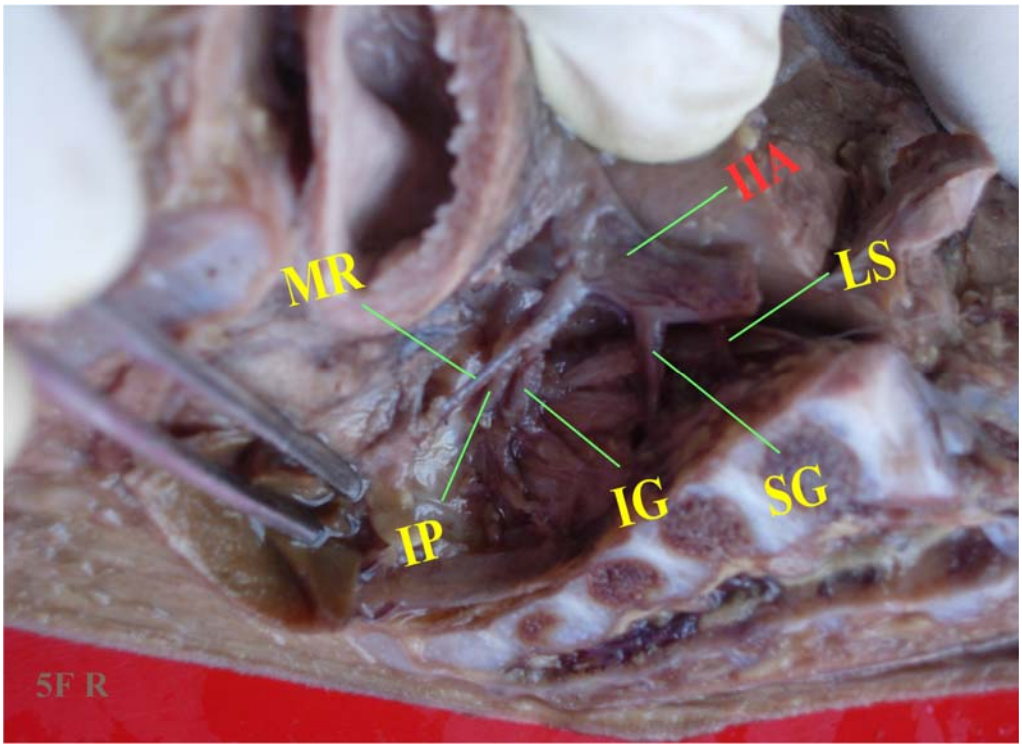


Picture 39: Abnormal Obturator artery coursing lateral to femoral ring.

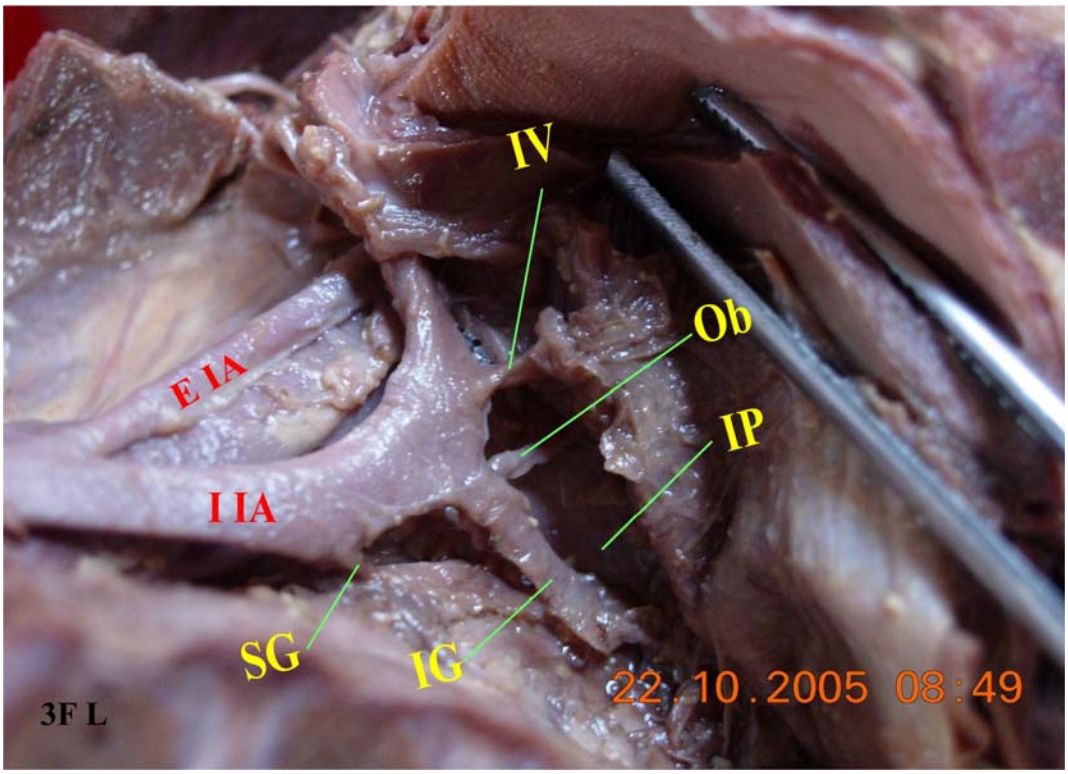


Picture 40: Two roots of Obturator artery;
Above: Left side and Below: Right side.

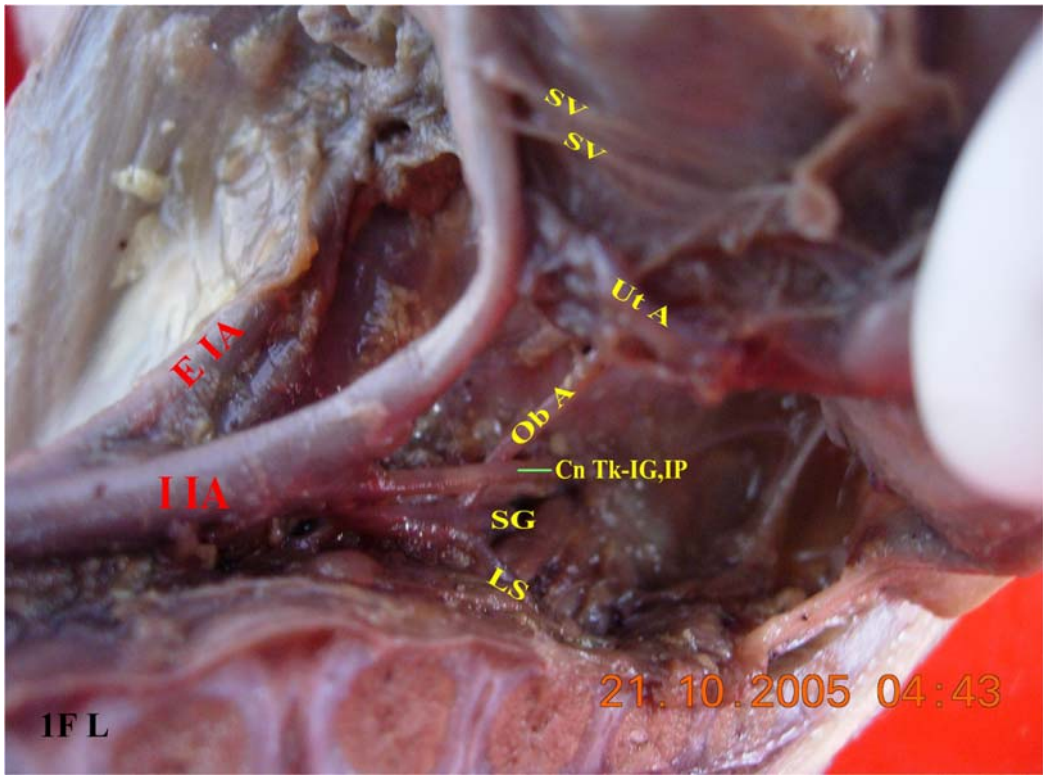
Picture 41: Bisected Fetal pelvis



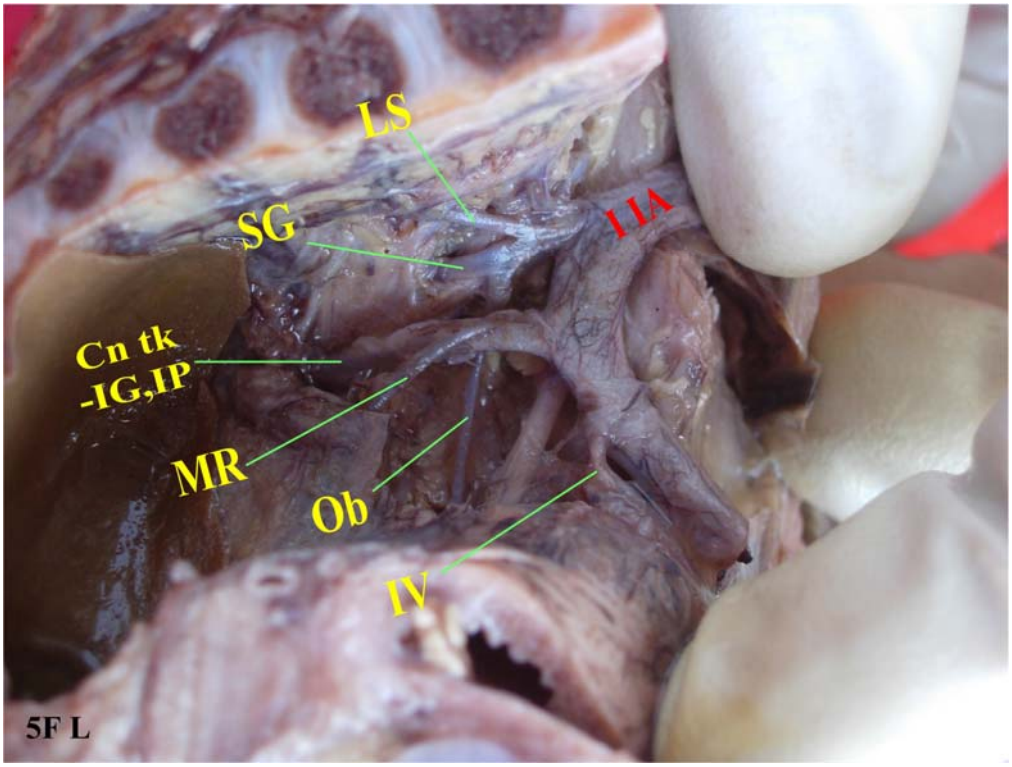
Picture 42:Common trunk for Inferior gluteal artery and Internal pudendal artery dividing proximal to pelvic floor



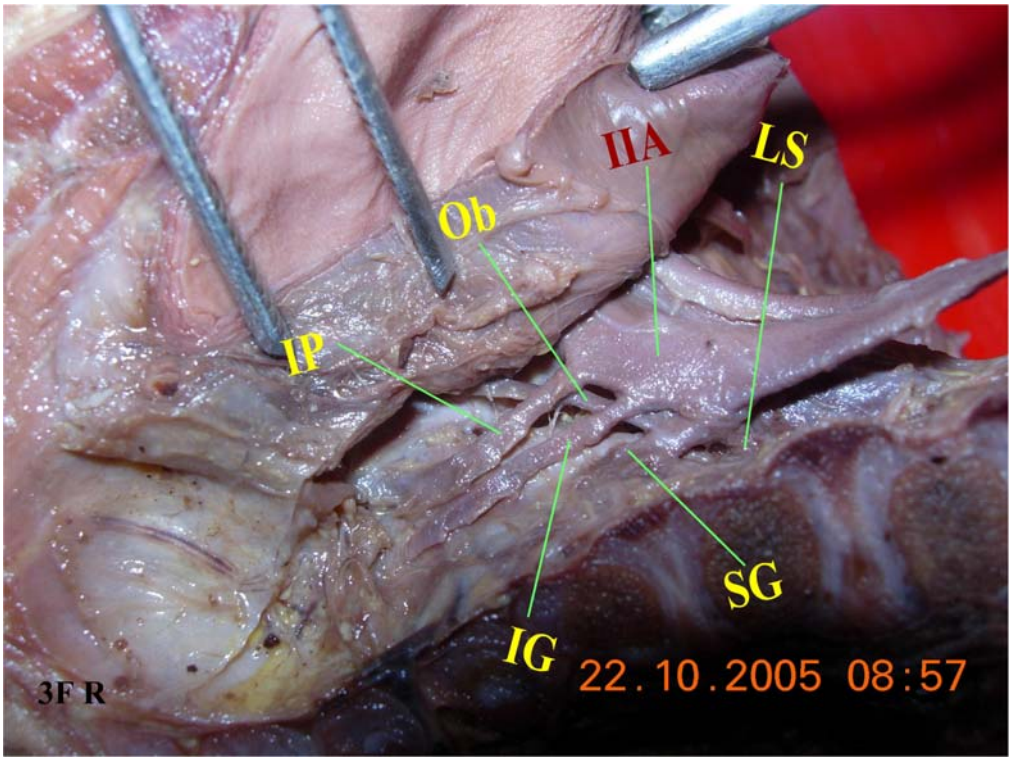
Picture 43: Obturator artery in common with Inferior gluteal artery and Internal pudendal artery



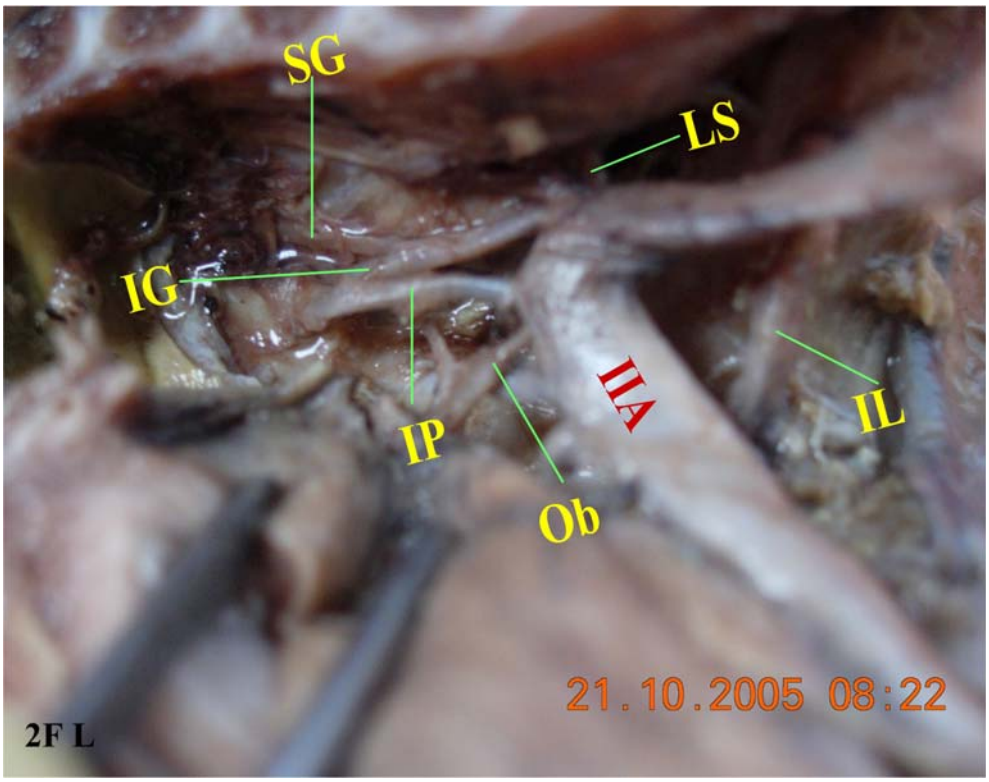
Picture 44: Uterine artery from Internal iliac artery



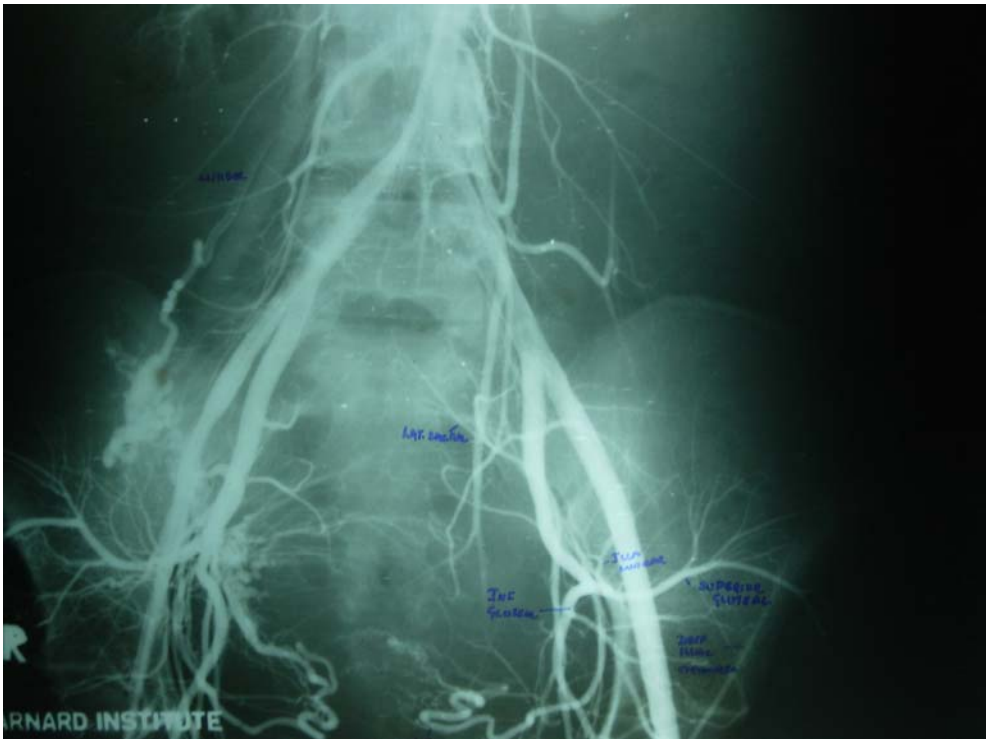
Picture 45:Common trunk for Inferior gluteal artery and Internal pudendal artery dividing distal to pelvic floor



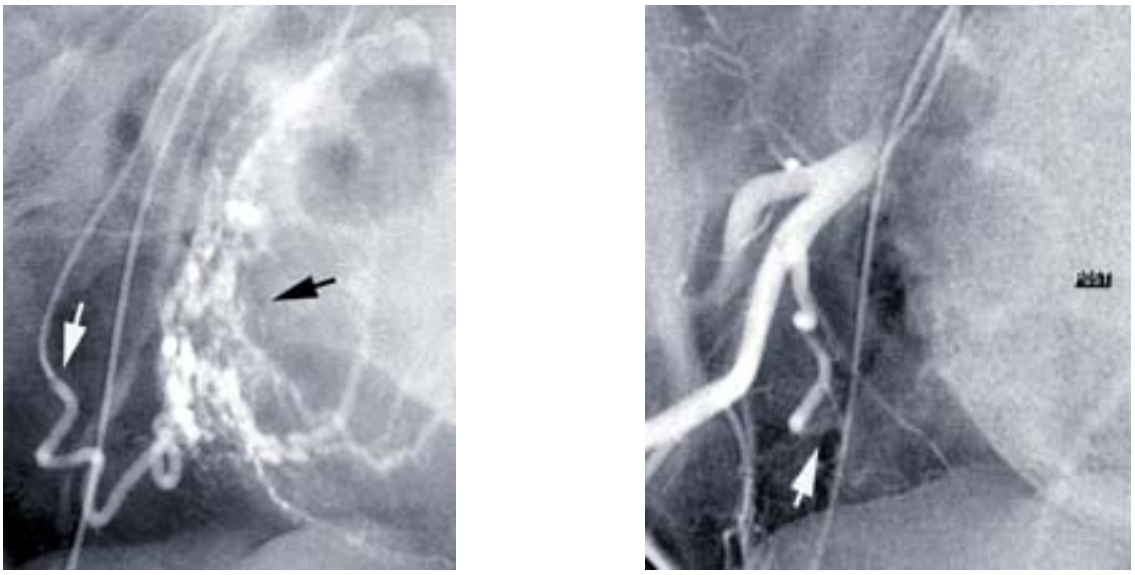
Picture 46: Inferior gluteal, Internal pudendal and Superior gluteal arteries arising separately from Internal iliac artery



Picture 47: Common trunk for Inferior gluteal artery and Superior gluteal artery arising from Internal iliac artery.

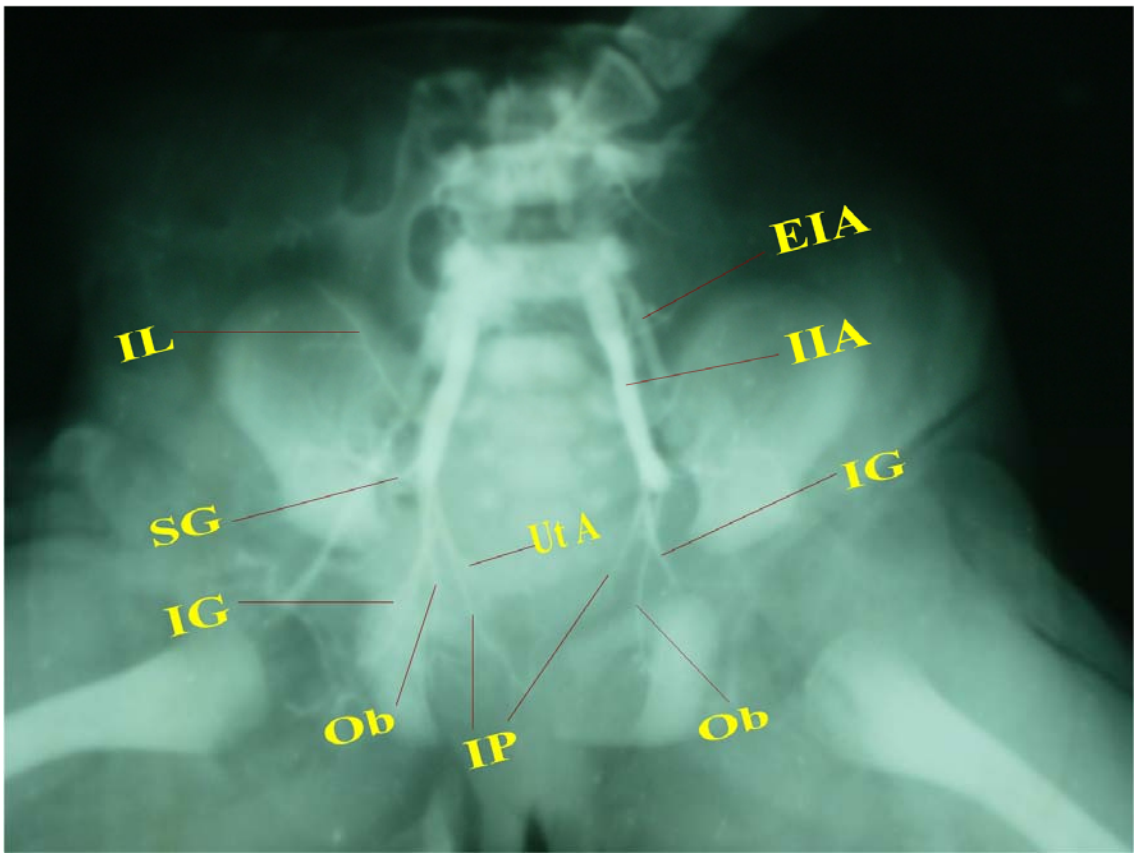


Picture 48: Adult pelvic angiogram



49 a **49 b**

Picture 49: Pelvic angiogram
a-Before uterine artery embolisation. b-After embolisation.



Picture 50: Fetal pelvic angiogram

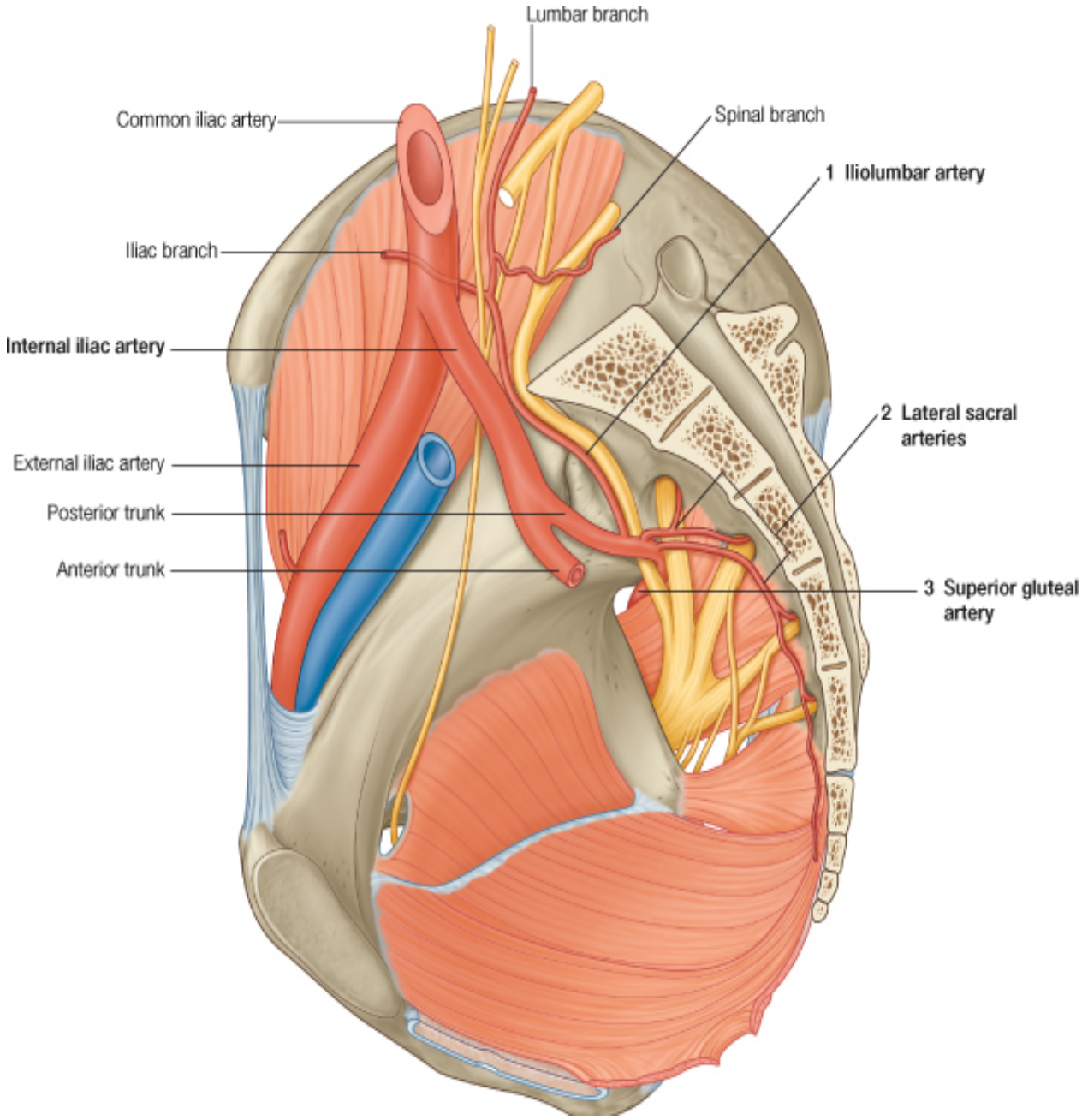


Fig 2: Branches of the posterior trunk of the internal iliac artery (Gray's Anatomy).

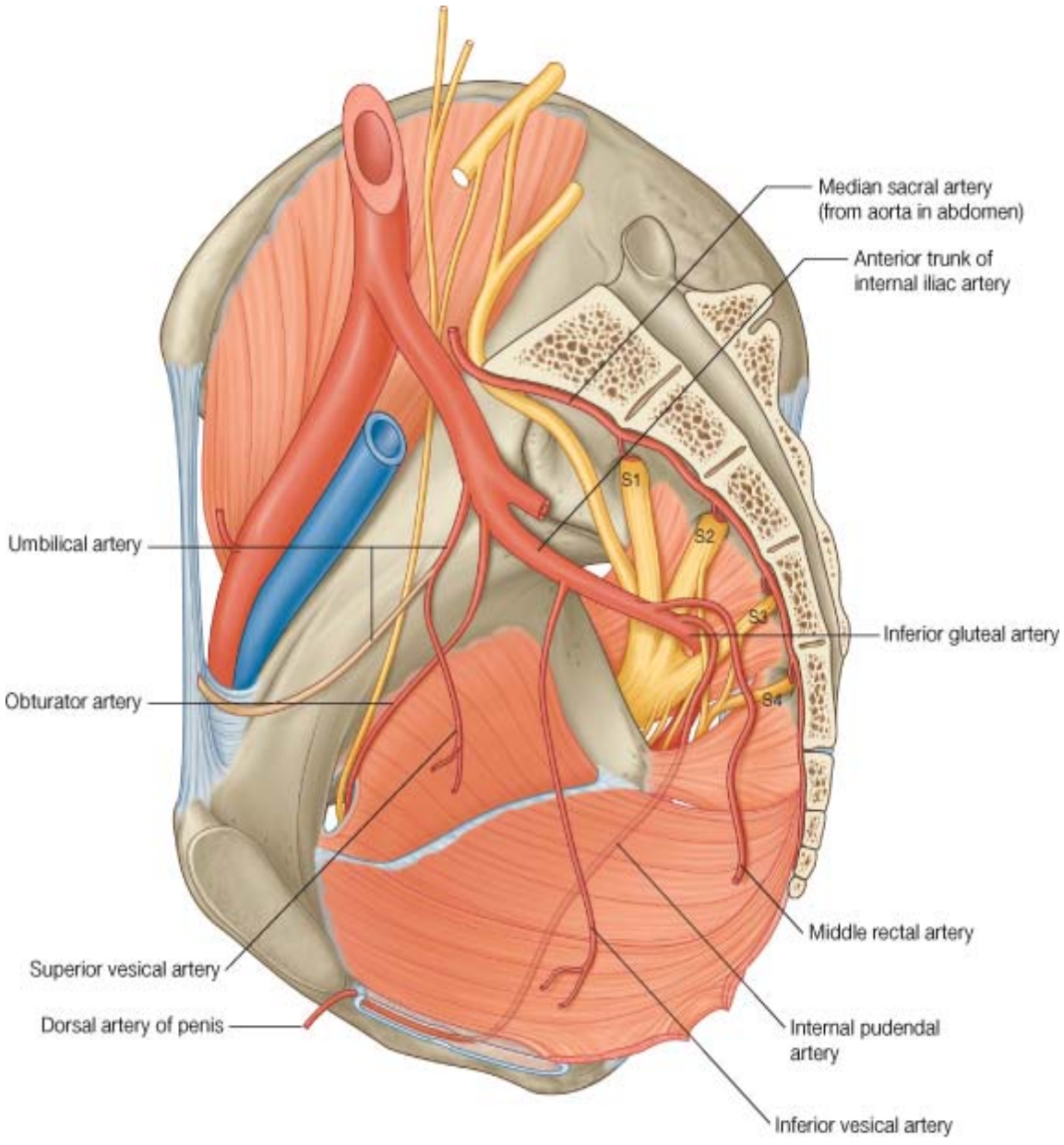


Fig 1: Branches of the anterior trunk of the internal iliac artery (Gray's Anatomy).

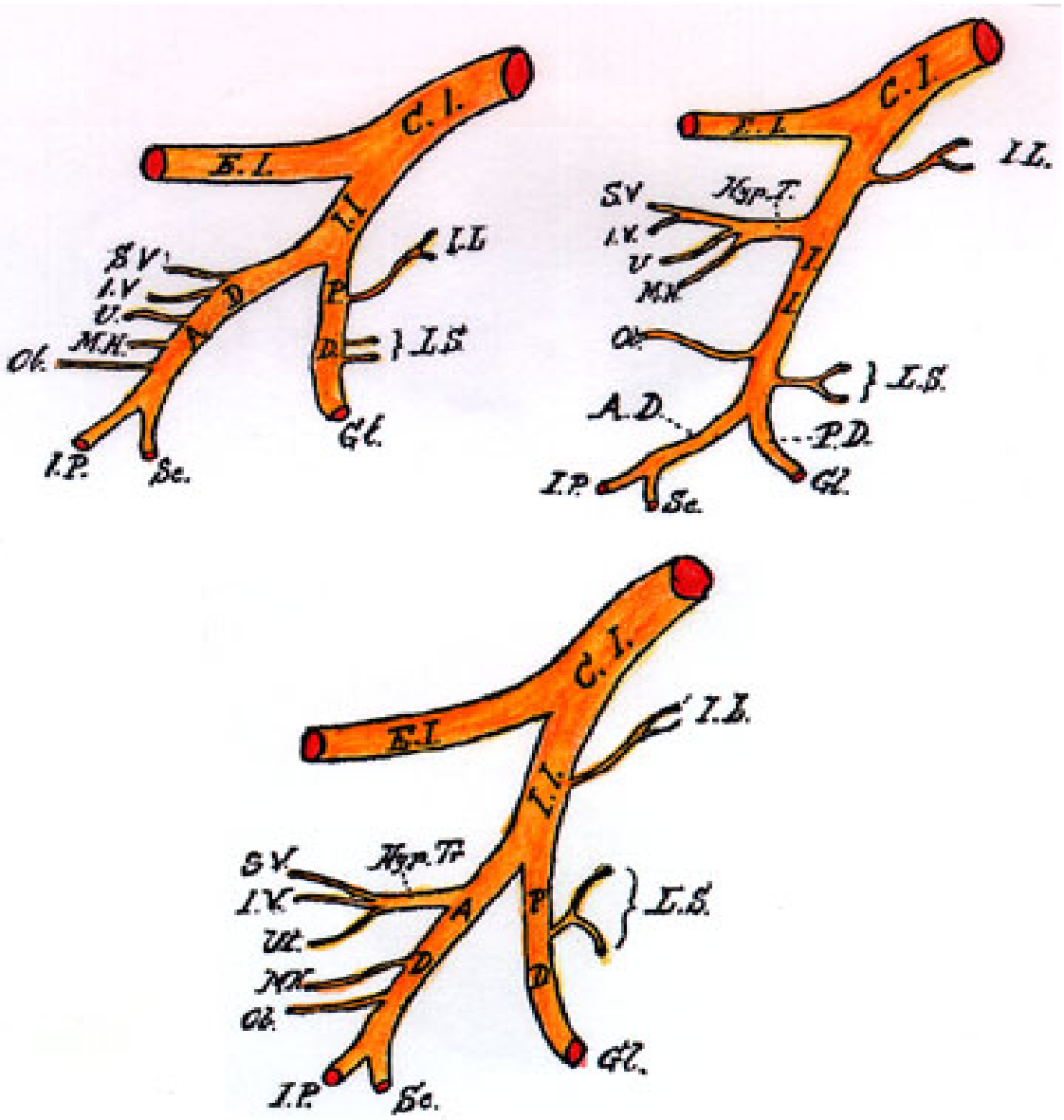


Fig 3: Formation of Hypogastric trunk

(Parson and Keith 1897)

C.I. = common iliac; E.I. = external iliac; I.I. = internal iliac; A.D. = anterior division; P.D. = posterior division; Hyp.T = hypogastric trunk; I.L. = iliolumbar; L.S. = lateral sacral; G l. = (superior) gluteal; S.V. = superior vesical; I.V. = inferior vesical; Ut. = uterine; V. = vaginal; M.H. = middle rectal; Ob. = obturator; I.P. internal pudic (pudendal); Sc. = sciatic (inferior gluteal).

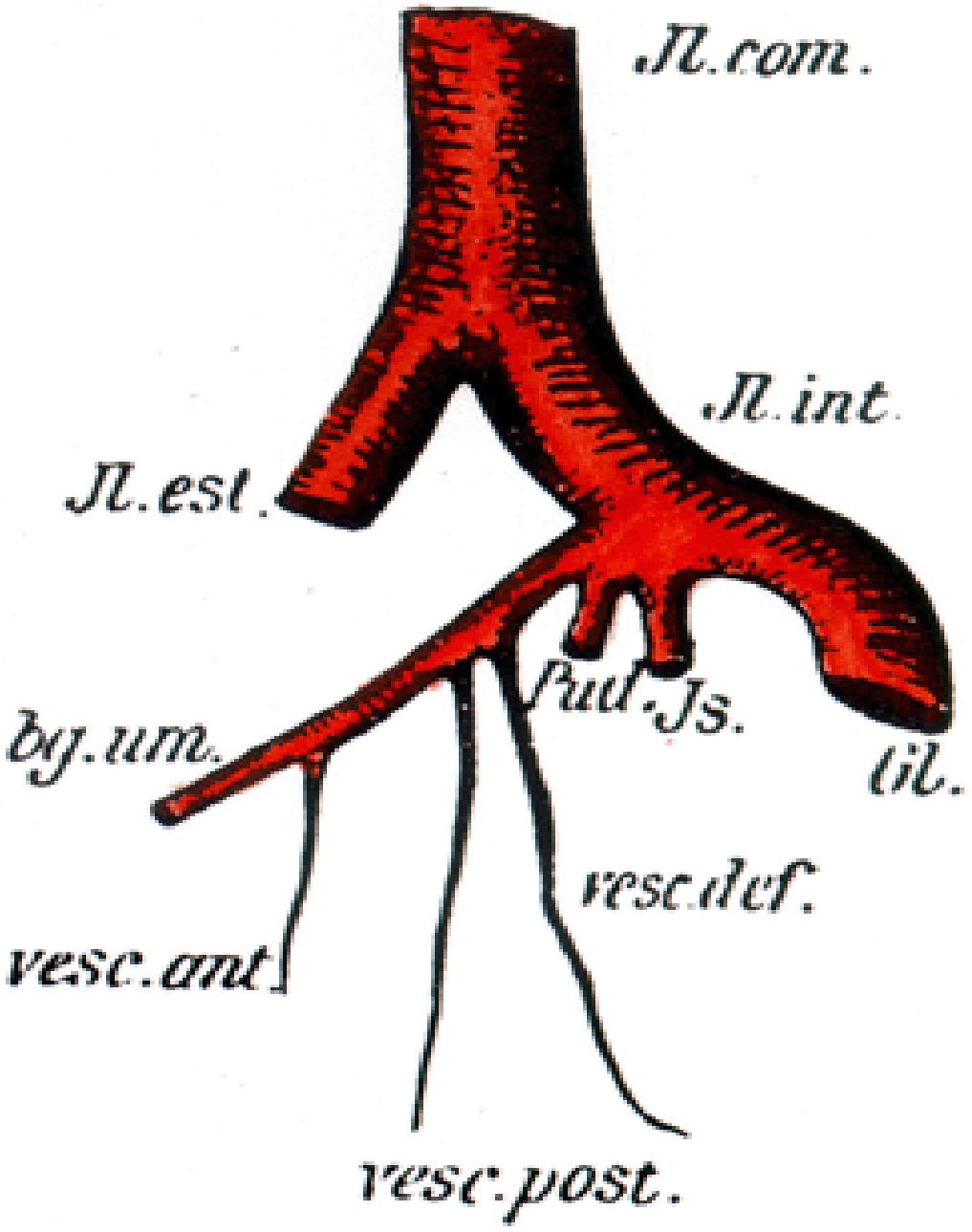
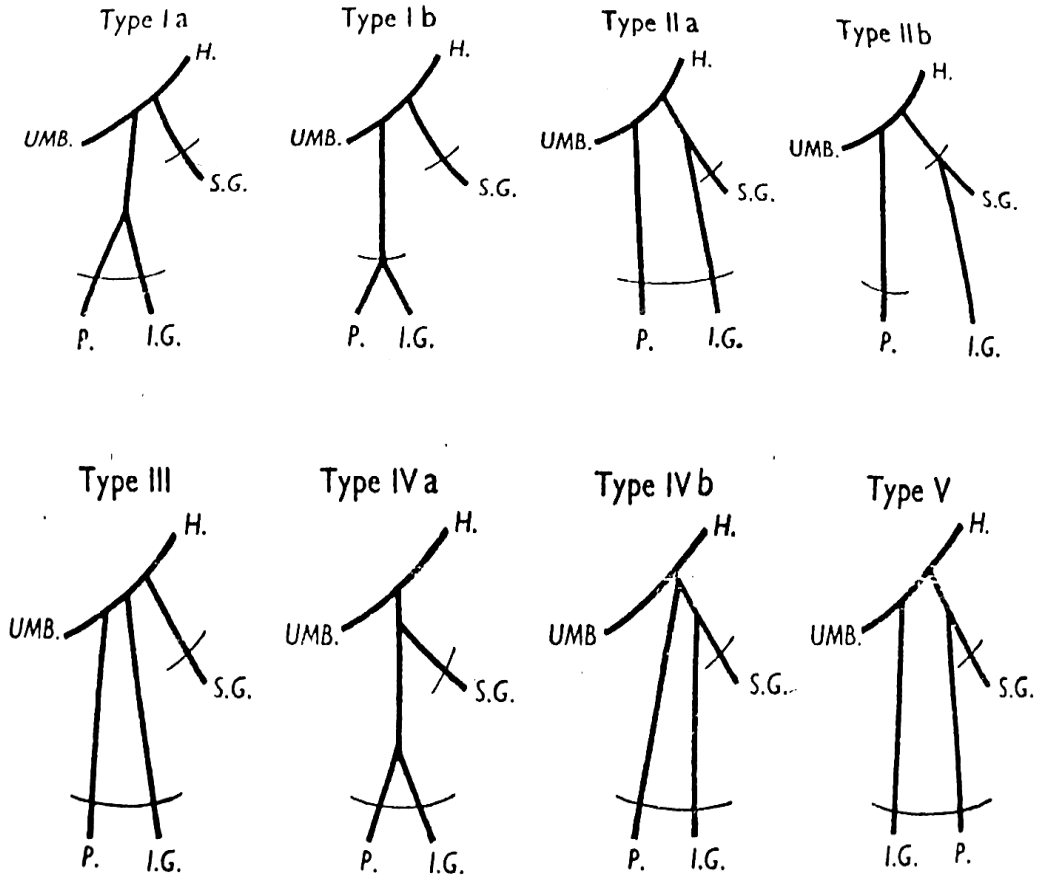


Fig 4: The umbilical artery gives rise to the vesico-deferential, superior vesical and inferior vesical arteries (Levi 1902).

JL. com._common iliac; JL. int._internal iliac; JL. est. _external iliac; bg.um._umbilical artery; Pud._pudendiae; Js._inferior gluteal; vesc. ant._superior vesical; vest.post._inferior vesical; vesc def._vesical deferentialartery



g. 1. Adachi's types. *H.* internal iliac artery; *I.G.* inferior gluteal artery; *P.* internal pudendal artery; *S.G.* superior gluteal artery; *UMB.* umbilical artery.

Fig 5: Adachi's classification

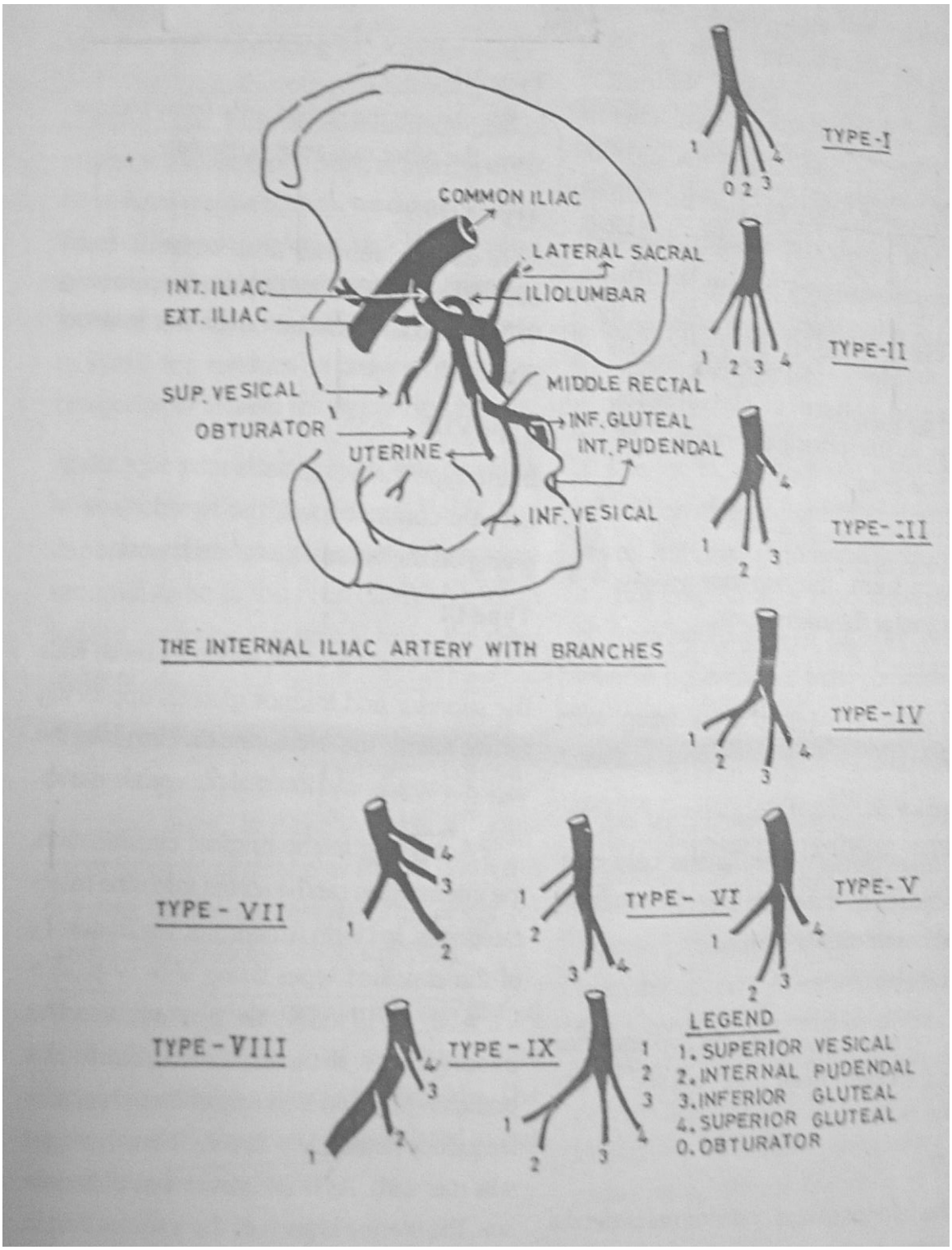


Fig 6: Anson and Ashley‘s classification

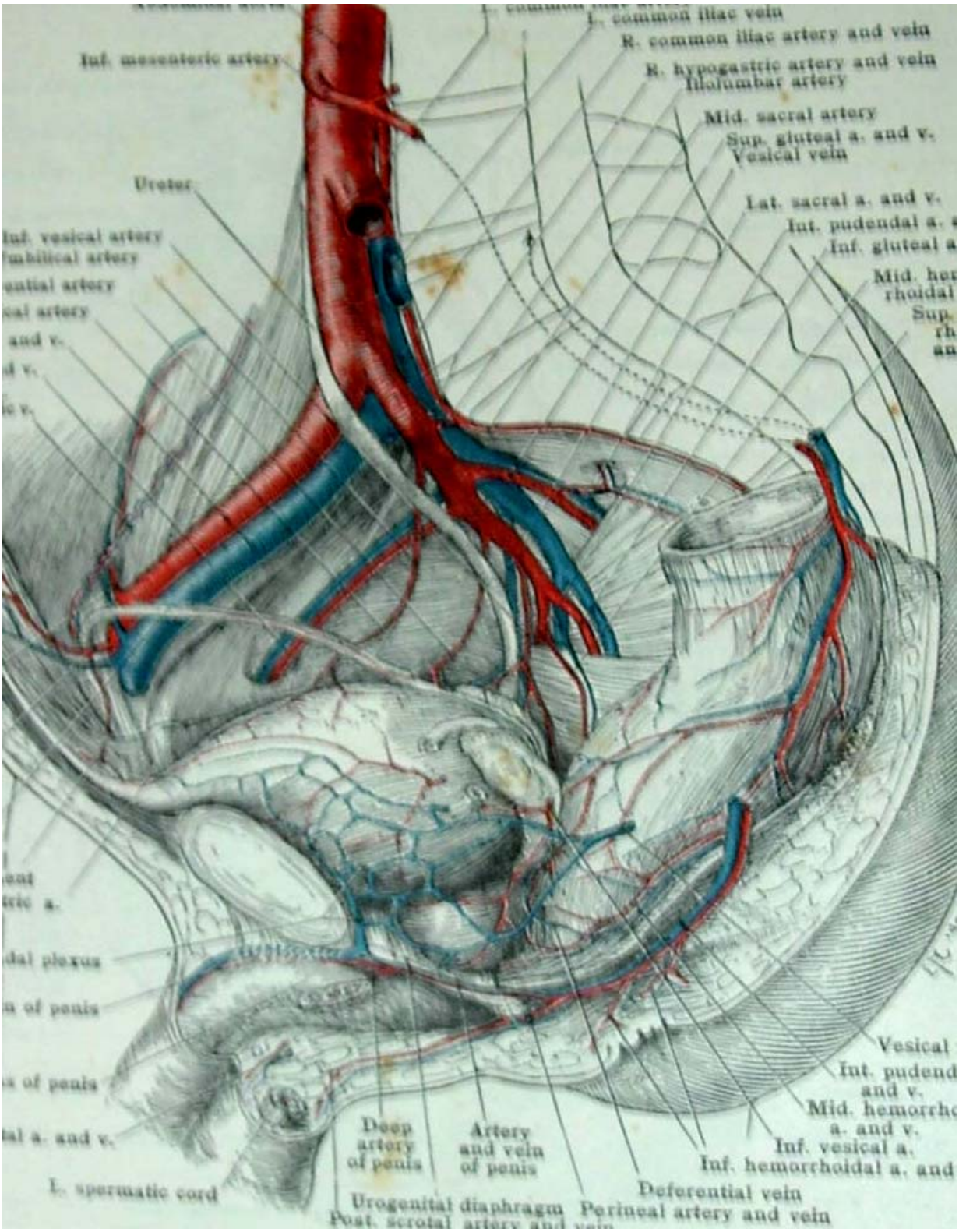


Fig 7: Hypogastric artery (Morris 1953)

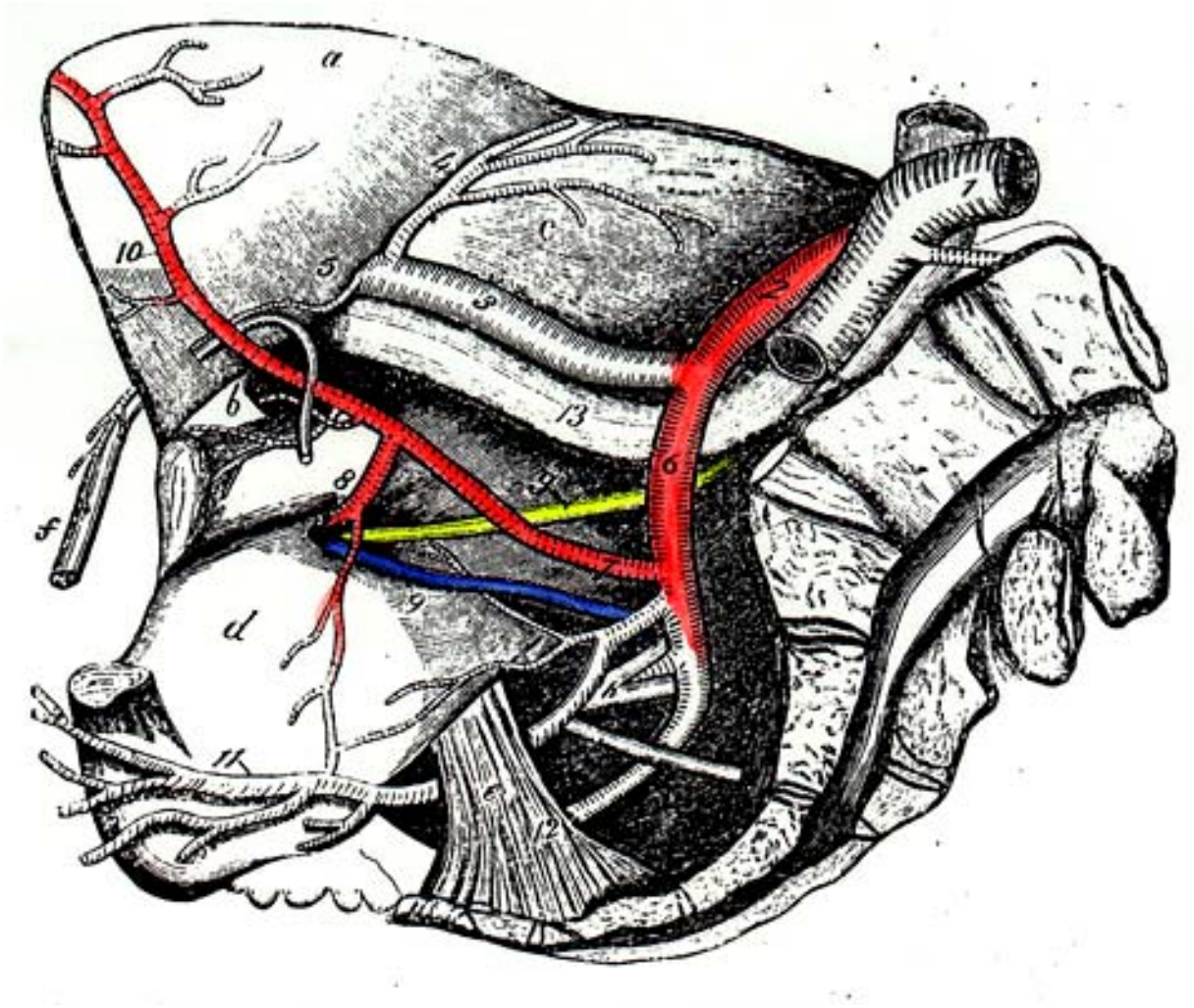


Fig 8: Common trunk for inferior epigastric artery and obturator artery (Redfern, 1850)

a, Triangular flap of the wall of the abdomen.
b, Gimbernat's ligament.
c, Iliacus muscle.
d, Obturator internus muscle, covered by fascia.
e, Coccygeus muscle and small sacro-sciatic ligament.
f, Spermatic cord.
g, Obturator nerve.
h, Nerves forming the sacral plexus.

Vessels.

1, Aorta.
2, Right common iliac artery.
3, External iliac artery.
4, Circumflex iliac artery.
5, Cremasteric artery arising from the external iliac.
6, Right internal iliac artery.
7, Common trunk of the obturator and epigastric arteries.
8, Obturator artery giving a branch to anastomose with the pudic.
9, Obturator vein.
10, Epigastric artery furnishing a branch to ramify behind the pubes, and another to pass through the crural ring.
11, Pudic artery.
12, Ischiadic artery.
13, Right external iliac vein.

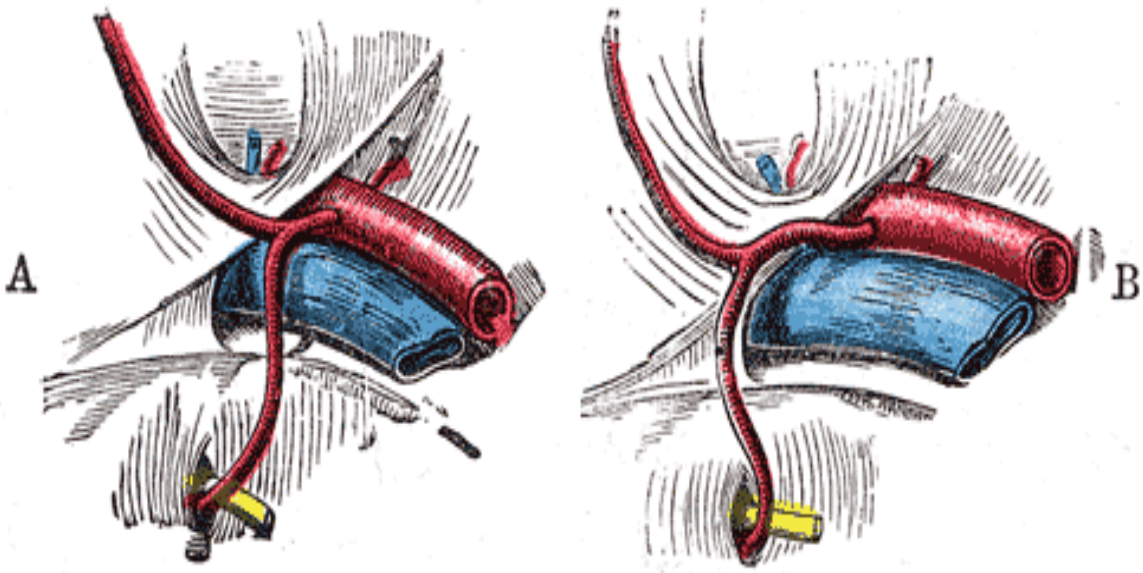


Fig 9: Relation of abnormal obturator artery to femoral ring (Gray 1901)

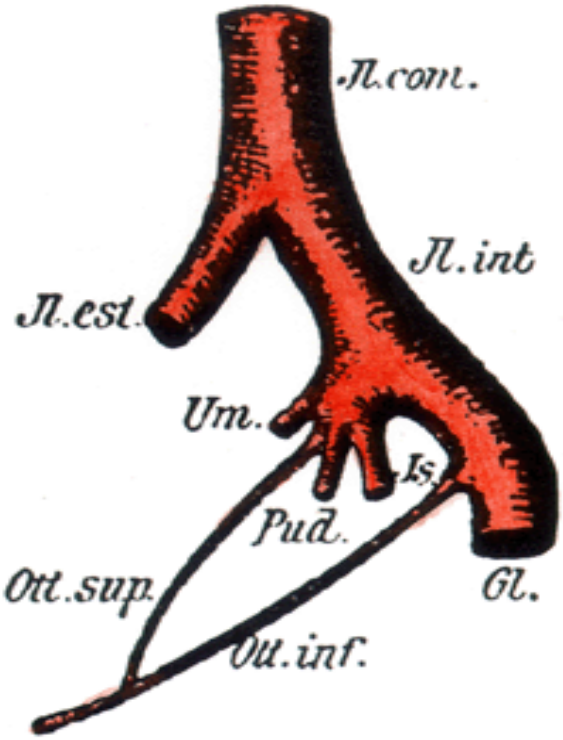


Fig 10: Origin of obturator from 2 branches (Levi 1902)

JL. com.-common iliac; JL. int.-internal iliac; JL. est.-external iliac; Um.-umbilical artery; Ott. sup.-obturator superior branchJs.-inferior gluteal; Pud.-pudendal; Ott. int.-second branch of obturator from superior gluteal (Gl.)

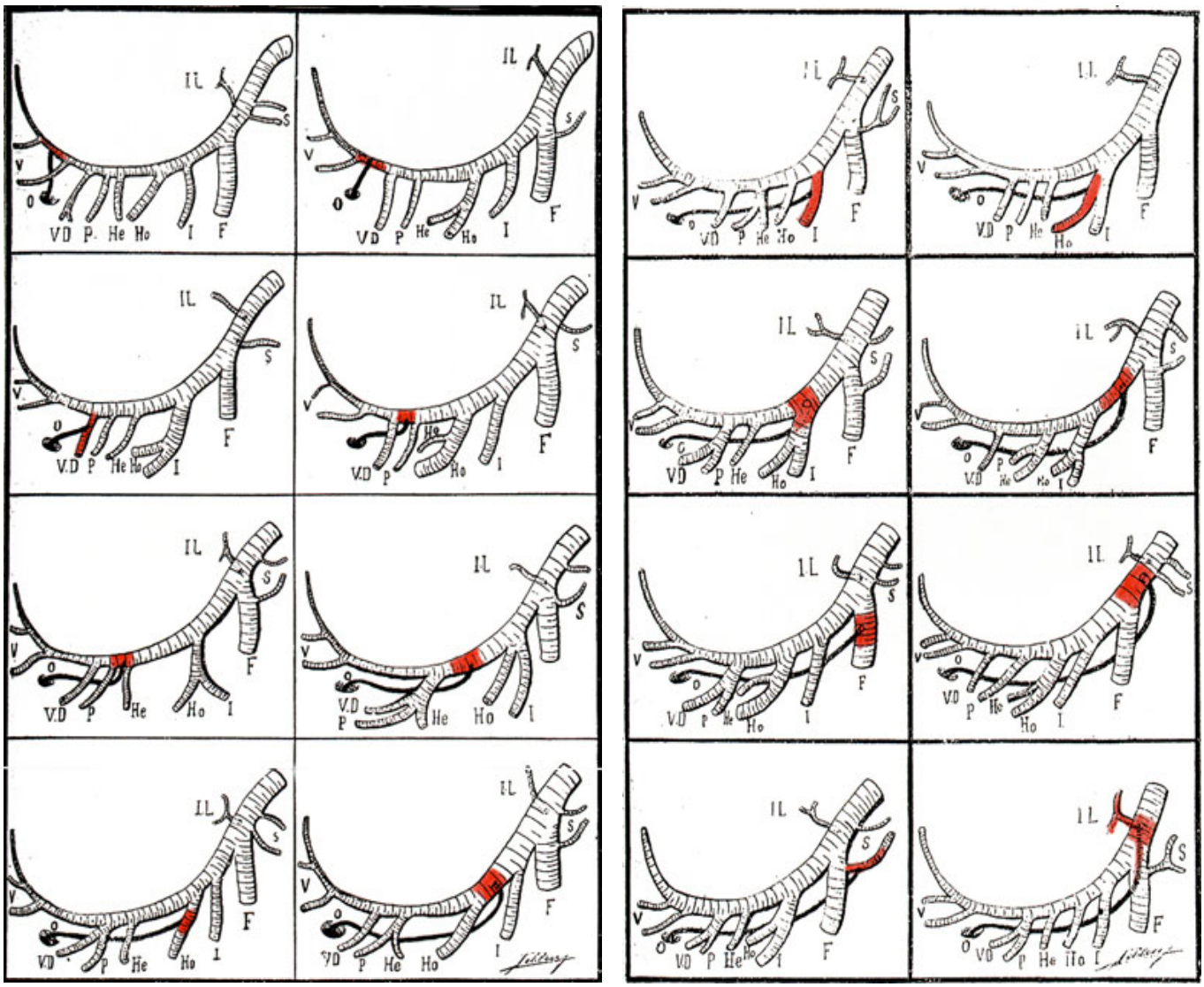


Fig 11: Origins of obturator artery (Dubreuil-Chambardel, 1925).

IL-iliolumbar artery; F-superior gluteal artery; I-inferior gluteal artery; Ho-internal pudendal; He-inferior rectal; P-prostatovesical artery; VD-vesicodifferential; V-superior vesical arteries; O-obturator

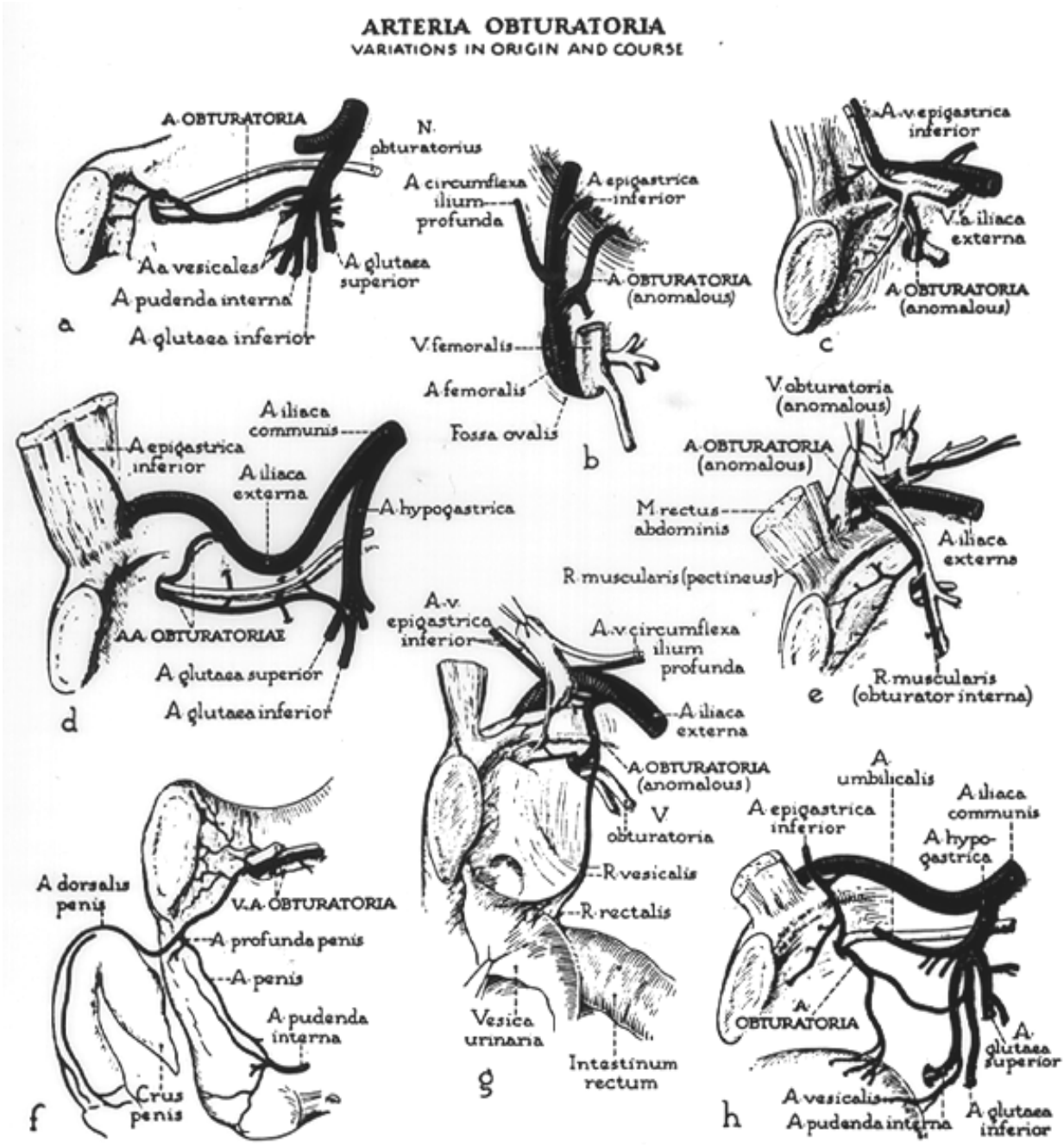


Fig 12: Variations in origin and course of obturator artery (Pick, Anson and Ashley, 1942).

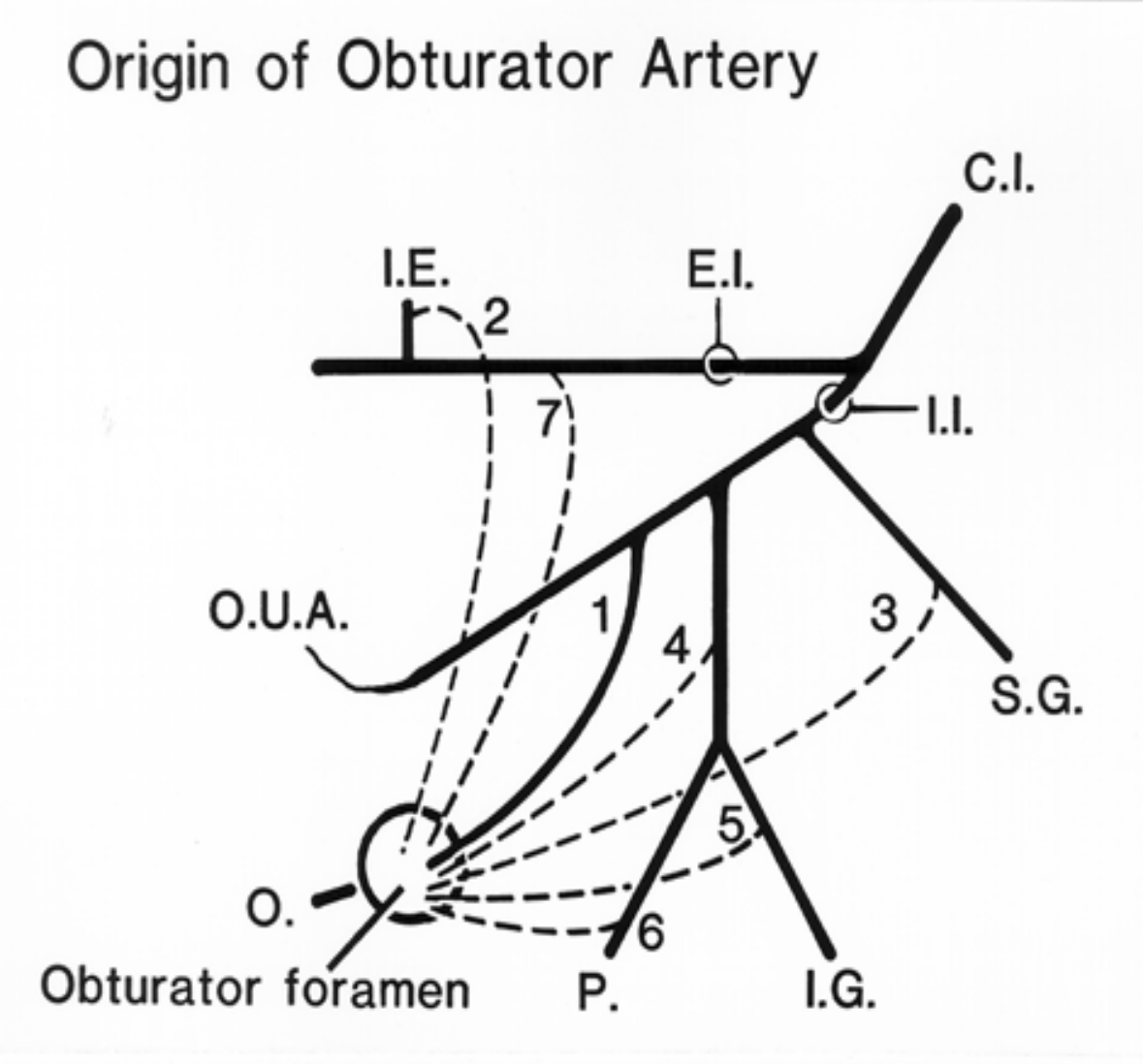


Fig 13: Origins of obturator artery (Braithwaite, J.L., 1952).

C.I.= common iliac artery, E.I.= external iliac artery, I.E.= inferior epigastric artery, I.G.= inferior gluteal artery, I.I.= internal iliac artery, O.= obturator artery, O.U.A .= obliterated umbilical artery, P.= pudendal artery, S.G.= superior gluteal artery.

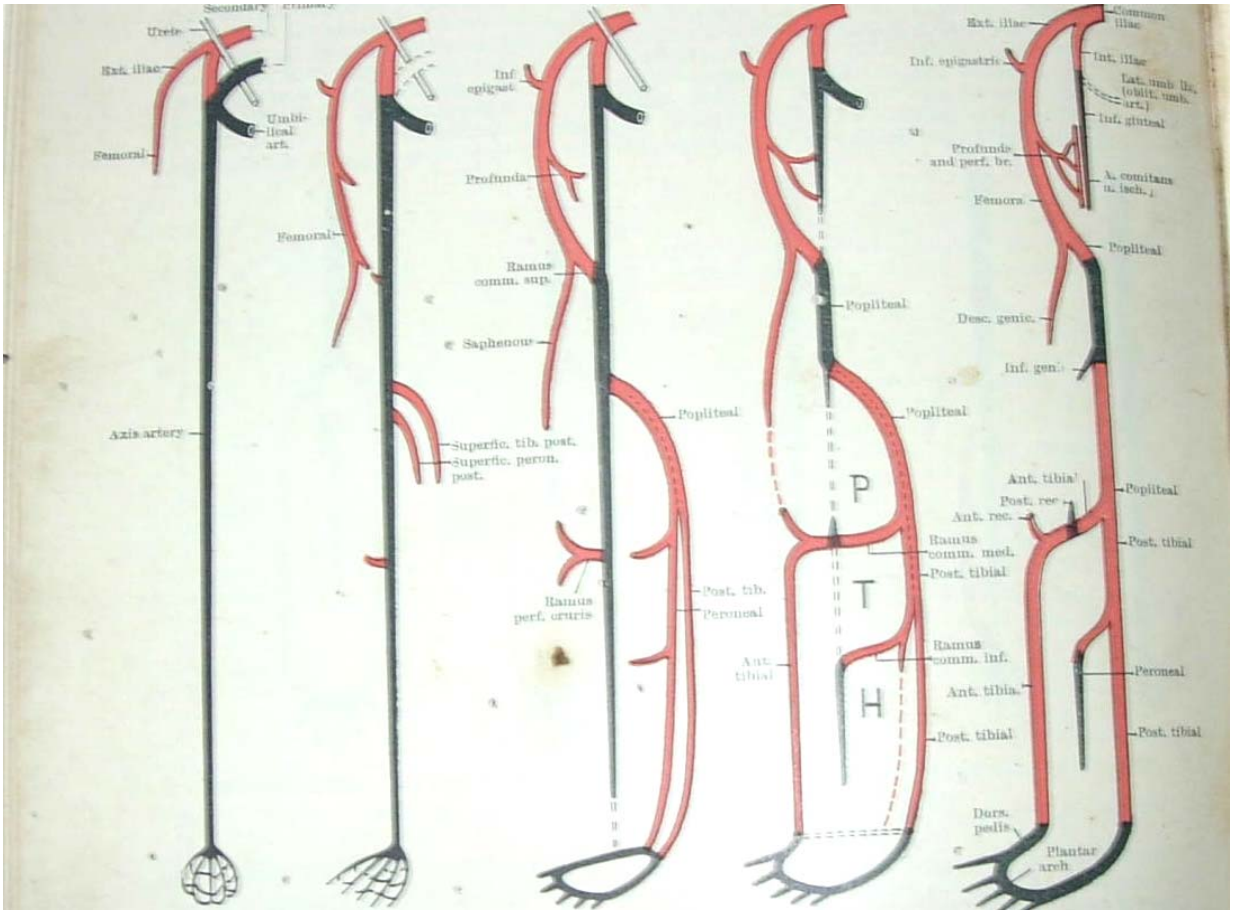


Fig 14: Embryology of internal iliac artery (Grant 1951)